Long-Term Methanol Vehicle Test Program

Final Subcontract Report 1 November 1992 – 1 February 1995

> J.C. Jones, T.T. Maxwell Texas Tech University Lubbock, Texas



National Renewable Energy Laboratory
1617 Cole Boulevard
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1. Background and Objective

Methanol, one of the leading alternatives to gasoline as a motor vehicle fuel, has been highlighted in national competitions such as the Society of Automotive Engineers (SAE) Methanol Marathon in 1989 and the SAE Methanol Challenge in 1990, but little has been done in the area of long-term testing of methanol as a motor vehicle fuel. To address this shortcoming, a 1988 Chevrolet Corsica was modified by Texas Tech University to serve as a test bed to determine the long-term effects of methanol on engine and emission systems performance. The vehicle was previously modified to operate on M85 for the SAE Methanol Marathon/Challenge competitions; it was further modified for M100 operation for the long-term test program.

The objective of this project was to determine the effects of methanol fuel on engine performance and exhaust emissions during long-term use. Engine wear, gasket performance, fuel economy, emissions level, oil consumption, and overall vehicle performance were monitored over approximately 22,000 miles of vehicle operation. Vehicle performance, oil consumption, and emissions baselines were established initially to be used for comparative purposes during the program. The engine was removed from the vehicle and disassembled, and all bearing and ring clearances and cam profiles were measured to determine any preexisting wear. All gaskets, seals, bearings, and piston rings were replaced. The cylinder bore was honed, valve and valve seats were lapped, and the crankshaft journals were polished. Higher flow rate fuel injectors supplied by AC Rochester were installed and the computer system was calibrated for M100 fuel.

At the completion of the program, after the mileage accumulation phase, the vehicle emissions level, oil consumption, and engine performance were again determined. The engine was removed from the vehicle, disassembled, and engine component wear was determined and compared with the initial condition.

2. Vehicle Modifications

The Corsica was initially modified to operate on M85 for the SAE Methanol Marathon/Challenge competitions [1 and 2]. The vehicle won 2nd place overall in the 1990 Methanol Challenge, placing 1st in endurance fuel economy, 2nd in acceleration, and demonstrating excellent emissions and maneuverability. Table 1 summarizes the major event rankings for the Texas Tech Corsica.

Table 1. Major Event Rankings for TTU Corsica in 1990 SAE Methanol Challenge

	2 nd Place	Overall							
1 st P	lace Enduranc	e Fuel Econom	ıy						
	2 nd Place Acc	eleration							
FT	P Emissions R	Results (g/mi)							
HC	0.04	NO _x	0.71						
NMHC	0.03	CH₃OH	0.29						
CO	0.60	OMHCE	0.16						
l (miles	TP Fuel Econo per gallon ga	omy Results soline equival	ent)						
Ci	City 21.6								
High	w ay	41	.0						
55/45 City	/Highw ay	27	.4						

A methanol-compatible fuel system (tank, pump, lines, fuel rail, and injectors) was installed for the SAE competitions. GM delivered the Corsica with a computer interface which allowed modifications to be made to the engine control maps during engine operation. The engine stroke was increased to take advantage of the increased amount of exhaust product and slower burning characteristics of methanol. To ensure good fuel economy, the bore was decreased to maintain a displacement of 2.8 liters. The crankshaft from a 1990 3.1-liter GM V-6 engine was used to achieve a stroke increase from 2.99 inches to 3.31 inches. Because methanol has a higher octane rating than gasoline, the compression ratio was increased to 11 7:1 by installing custom flat-top pistons with a centered pin-bore. The piston material contains a high silicon content for low coefficient of thermal expansion, good wear resistance, and high-temperature strength. The top piston ring was changed to a chrome ring to maximize the amount of heat retained in the combustion chamber to enhance the vaporization of fuel. The oil ring was also changed to reduce friction. A custom camshaft was employed to compensate for the slow burn characteristics of methanol. The lobe centers and duration were changed to allow a longer burn time during the power stroke. Cam specifications are presented in Table 2. Roller-tip rocker arms were used to reduce friction and valve guide wear. To compensate for the increase in exhaust flow, a larger 2-1/4inch exhaust pipe diameter was used between the exhaust manifold and the catalytic converter. From the catalytic converter, the exhaust pipe diameter is 2-1/2 inches. Allied-Signal, Inc., Tulsa, Oklahoma, provided the specially designed light-off and main catalysts to control exhaust emissions. The light-off converter is located near the exhaust manifold in order to reach operating temperature as quickly as possible after engine start. Heated air from around the exhaust manifold is supplied to the air cleaner at temperatures below 30°C to enhance cold starting and driveability.

To increase fuel economy, the 5th gear ratio was lowered from 0.72:1 to 0.603:1. This resulted in a decrease in engine speed at 60 mph from 2200 to 1875 rpm. This modification takes advantage of the increased torque the engine produces. To prevent body roll in tight cornering, a larger sway bar and gas shocks were installed at the rear axle. These additions provided greater driving stability to the vehicle.

3. Engine Calibration and Fuel Properties

At program initiation after the engine was installed in the Corsica, chassis dynamometer testing was accomplished for engine/vehicle final calibration and performance evaluation. Rich conditions under deceleration were experienced and could not be corrected due to lack of electronic control module (ECM) deceleration table addresses. As a result, the vehicle experienced a slight idle instability after deceleration to a stop. The ECM calibration tables are included in Appendix A. Engine starting was acceptable at temperatures above 15°C, but considerable difficulty was experienced in starting the vehicle during winter conditions. As a result, the engine accumulated an abnormal amount of time under cold-cranking conditions with inadequate lubrication

A problem arose during the pretest engine dynamometer testing with the M100 fuel. This fuel had been stored for over a year, and upon opening a 55-gallon drum an atypical smell was noted as compared to that of M100 racing fuel. This fuel was used during the first series of dynamometer tests and the engine control system calibration

Cyl 1 Cyl 2 Cyl 3 Cyl 4 Cyl 5 Cyl 6 Variance Avg ntake & Exhaust Lobe Center Sep 111.1 111.0 110.9 110.8 111.1 111.1 111.0 0.3 Cam Deg Valve Overlap -27.6 -27.5 -27.2 -27.2 -27.8 -28.0-27.50.4 Crank Angle ntake Valve Opening -7.8 -7.8 -7.6 **-**7.6 -7.9 -8 -7.8 0.2 Deg BTDC

104.3

22.2

194.6

0.25988

0.38982

34

117.3

-19.6

194.4

0.25906

0.38858

18.53

18.61

104.5

22.2

194.3

0.25854

0.38781

18.47

34.1

117.6

-19.9

194.2

0.25902

0.38852

18.46

104.5

22.1

194.1

0.2585

0.38776

34

117.5

-20

194

0.25906

0.38858

18.44

18.45

104.5

22.3

194.5

0.25957

0.38936

18.57

34.1

117.5

-19.8

194.3

0.25914

0.38871

18.49

0.1

0.2

0.3

0.09

0.1

0.1

0.2

0.2

0.05

0.00016

0.00024

0.00091

0.00136 Inch

Deg ATDC

Deg ABDC

Crank Deg

In * Deg

Deg BTDC

Deg ATDC

Deg ABDC

Crank Deg

Inch

nch

in * Deg

Inch

Table 2. Camshaft Specifications as Measured with the Cam Doctor

104.6

22.5

194.7

0.26031

0.39047

18.61

34.1

117.5

-19.8

194.3

0.25933

18.47

0.389

104.5

22.5

194.7

0.26028

0.39041

18.64

34.2

117.5

-19.8

194.4

0.25917

0.38876

18.54

104.4

22.2

194.6

0.25992

0.38988

18.63

33.9

117.4

-19.6

194.3

0.25921

0.38882

18.5

Lobe Center

Valve Closure

Max Cam Lift

Net Valve Lift

Valve Opening

Lobe Center

Duration

Valve Closure

Max Cam Lift

Net Valve Lift

Lobe Area

Lobe Area

Exhaust

Duration

was difficult due to extremely rich conditions and exhaust temperatures were lower than typical. After a few minutes of operation the $\rm O_2$ sensor failed. The fuel was then tested using a procedure developed by V-P Hydrocarbons, which involves the addition of 10 parts hydrochloric acid and calcium chloride solution, 5 parts phenolphtalein and methanol solution, and 10 parts sodium hydroxide solution to 30 parts of the tested methanol. The result was a very cloudy solution, which, according to the test protocol, was unacceptable. Laboratory-grade methanol (99.98%) was also tested and resulted in a clear solution. The fuel was also used in the vehicle after the engine was reinstalled. When driving, a wide variance in the block learn memory was noted; thus, the engine idle was erratic and unstable. Occasionally, the engine would die during rapid acceleration.

Air Products and Chemicals, Allentown, Pennsylvania, which was providing the M100 for the program at no cost, was contacted and two samples of the fuel were sent to them for analysis. Gas chromatographic analysis of the samples did not disclose any obvious reasons why this fuel did not perform satisfactorily in the Corsica. This fuel was discarded and fresh fuel from the Air Products facility in LaPorte, Texas, was used during the remainder of the program without any further problems. Table 3 shows assays of the typical product and the two samples analyzed by Air Products.

Table 3. Methanol Composition

Constituent	M100 Assay (Wt.%)	Sample 1 (Wt. %)	Sample 2 (Wt. %)
1. Methanol	96.590	97.030	97.060
2. Dissolved Gases (Air+CO ₂)	0.126	0.000	0.000
3. Dimethyl Ether	0.012	0.000	0.000
4. Methyl Formate	0.924	0.700	0.700
5. Water	0.605	0.550	0.550
6. Ethanol	0.678	0.630	0.640
7. Methyl Acetate	0.166	0.140	0.130
8. n-Propanol	0.260	0.320	0.320
9. Methyl Ethyl Ketone	0.048	0.010	0.010
10. SEC-Butanol	0.029	0.040	0.030
11. ISO-Butanol	0.036	0.030	0.030
12. N-Butanol	0.137	0.120	0.120
13. ISO-Pentanol	0.038	0.070	0.060
14. 1-Pentanol	0.080	0.060	0.060
15. N-Hexanol	0.034	0.030	0.020
16. Aliphatic Oil	0.235	0.010	0.040
17. Isopropanol	0.000	0.010	0.010
18. t-Butanol	0.000	0.006	0.008
19. Unknowns	0.000	0.240	0.210

4. Mileage Accumulation

The mileage accumulation phase of the project occurred between the initial and final Federal Test Procedure (FTP) testing at Southwest Research Institute (SwRI) (from January 1993 to December 1994). The vehicle was driven under city and highway conditions and relatively few problems were experienced. The hydraulic clutch slave cylinder failed during a full-throttle acceleration drive and the mass air-flow sensor was replaced after the mounting boss broke. The vehicle pulled a two-wheel trailer loaded with two 55-gallon drums of methanol from Lubbock to San Antonio, Texas and Lubbock to Austin, Texas with exceptional performance. Figure 1 shows the Corsica during a road trip to San Antonio. Note the fuel trailer necessary for long trips. The vehicle was exhibited during the 4th Annual Texas Alternative Fuels Market Fair and Symposium in Austin on June 6-8, 1993, and participated in the 1993 Fourth of July parade in Lubbock, Texas. Figure 2 shows the vehicle on display at the Market Fair in Austin, Texas.

The only serious problem encountered during the mileage accumulation phase of the program was related to fuel pump failures. In March 1994 the original fuel pump in the vehicle failed. This pump had been in the vehicle since the inception of the long-term methanol program but was the third pump installed in the vehicle during the two years of competition (1989-1990). At the time of failure this pump had been in service for approximately two years. Contact with AC Rochester at the time of failure indicated that this particular pump was subject to electrical contact corrosion in which copper from the electrical contact was taken into solution with the methanol. When

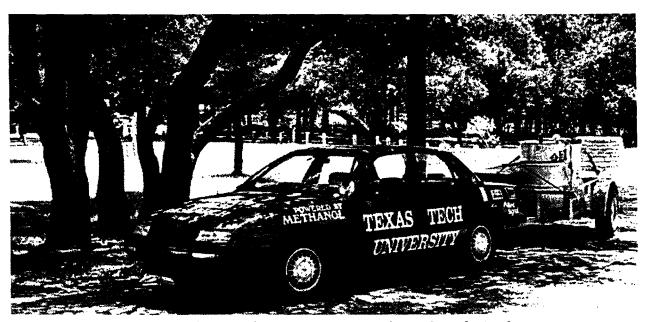


Figure 1. Test vehicle during road trip to San Antonio

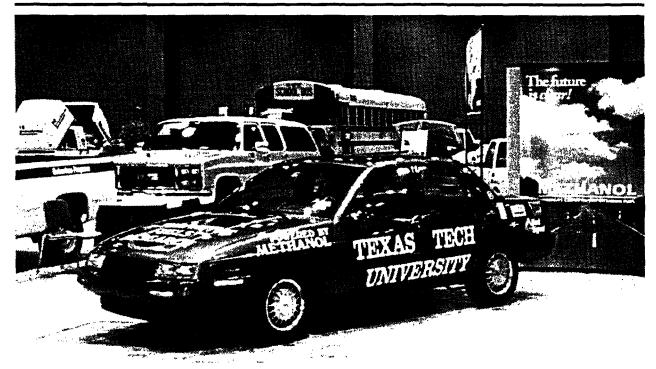


Figure 2. Test vehicle on display at the 4th Annual Texas Alternative Fuels Market Fair and Symposium in Austin

the amount of copper reached a certain level it appeared to precipitate out of solution and clog the pump, rendering it inoperative.

The failed pump was replaced with a new pump obtained from AC Rochester. The replacement pump lasted only a few minutes before it also failed. AC Rochester personnel indicated that some pumps were manufactured with inadequate plating and that the type of failure experienced with this second pump was characteristic of this manufacturing problem. A third pump obtained from AC Rochester was then installed in the vehicle in late June 1994. This pump also failed shortly thereafter (approximately two weeks). This pump was returned to AC Rochester and from there was passed on to the General Motors Corporation (GM) Fuels and Lubricants Department for analysis. A fuel sample was also sent to GM since it was suggested that the M100 might be contributing to the failures. Personnel from Air Products and Chemicals were also brought into the failure analysis discussions at this time since they provided the M100 for the program. No report us to the results of this analysis was provided by GM.

A methanol-compatible fuel pump was then purchased from the local GM performance parts supplier. This pump was preconditioned by pumping gasoline through it for several hours before installing it in the vehicle. This pump performed satisfactorily for the remainder of the program (approximately six months).

5. Engine and Component Wear

Tear-down of the engine after the mileage accumulation showed indications of detonation in three cylinders and significant wear and scuffing on one cylinder wall. Cylinders 1, 2, and 6 showed normal wear of approximately 0.0005 in cylinder diameter. Figure 3 shows the piston from Cylinder 2 after removal from the engine. The pistons from Cylinders1 and 6 are similar. There is no indication of wear on the piston itself and the rings still show the initial marks and imperfections. Note also the dark portion of the top of the second ring, which indicates that only a portion of the ring surface was in contact with the cylinder wall. Finally, there is no indication of combustion products or carbon buildup between the first and second rings of pistons from Cylinders 1, 2, and 6.

Cylinders 3 and 5 showed evidence of some detonation. The undersides of both pistons were lightly discolored, indicating excess heating typical of the higher temperatures produced by detonation. The rod bearings from these cylinders also showed some deformation typical of detonation. The piston from Cylinder 3 is shown in Figure 4. Note the dark deposits between the first and second rings. These deposits often result from detonation-produced flutter of the top piston ring. Also note that the top ring is very polished which indicates more than normal wear.

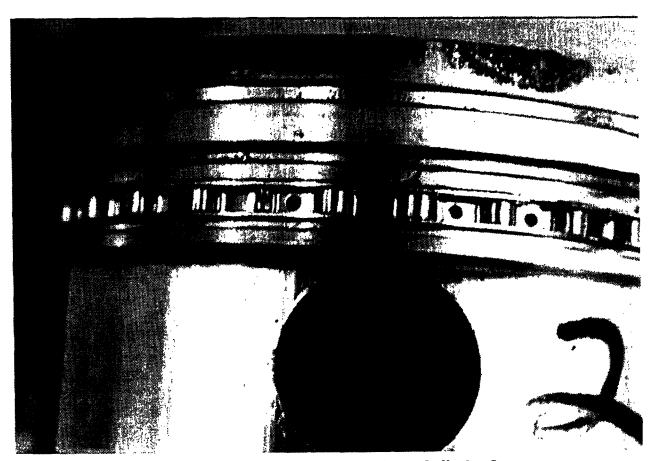


Figure 3. Side view of piston from Cylinder 2

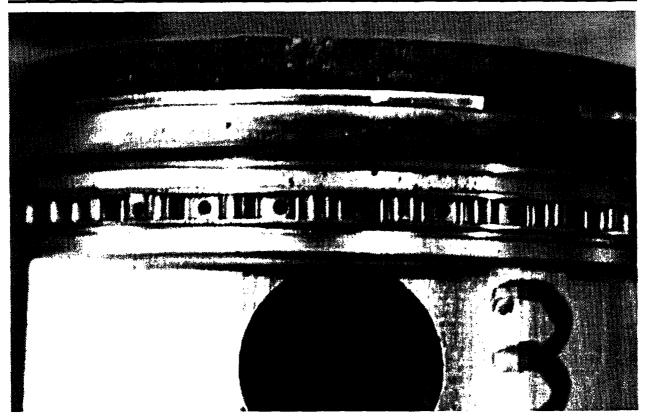


Figure 4. Side view of piston from Cylinder 3



Figure 5. Side view of piston from Cylinder 4



Figure 6. View of piston from Cylinder 4

Cylinder 4 showed the most significant abnormal wear. Views of the piston from Cylinder 4 are shown in Figures 5 and 6. Both the top and second ring show polished surfaces, indicating excessive wear for 22,000 miles of operation. There are almost no signs of the original markings on the rings. Some indication of scuffing of the piston surface between the rings is also apparent. Scuffing of the piston below the oil ring is clearly evident in Figure 6. The wall of Cylinder 4, depicted in Figure 7, clearly shows excessive scuffing. Note that the scuffing extends all the way to the top of the cylinder, above the highest position of the top ring. The scuffs in the cylinder become more pronounced at a point on the cylinder wall which coincides with the piston location a few crankshaft degrees past TDC, approximately where the force on the piston due to the combustion gases rapidly increases. The bottom of Piston 4 showed excessive heating and the rod bearings from Cylinder 4 were deformed in a manner typical of detonation. Cylinder 4 experienced the most severe detonation. Figure 8 shows the combustion chamber for Cylinder 4. Note the absence of the ceramic insulator in the spark plug. The insulator was probably dislodged by detonation. Otherwise the combustion chamber was clean and relatively free of deposits.

The wear experienced in Cylinder 4 and, to a lesser extent, in Cylinders 3 and 5 (see Tables 4 and 5), is thought to be related to the washing down of the cylinder walls by fuel during coldstarting. The engine was very difficult to start during the winter

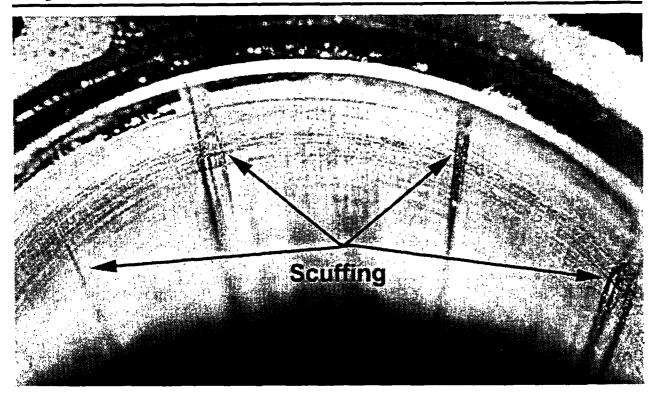


Figure 7. View of cylinder wall in Cylinder 4

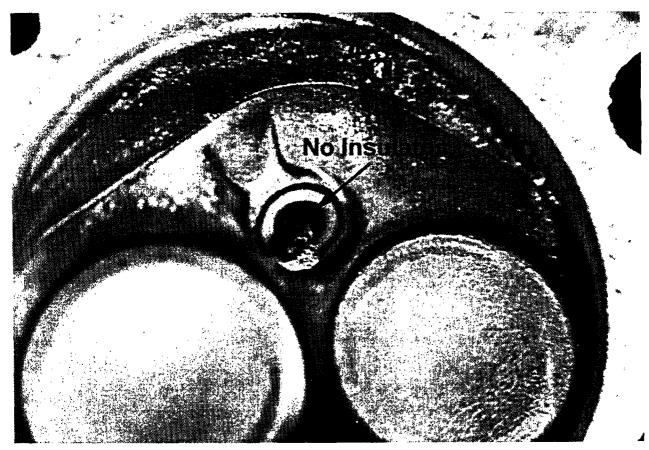


Figure 8. Cylinder head showing Cylinder 4 combustion chamber

Table 4. Short-Block Measurements Before Mileage Accumulation

		Cylinder	block			_
Cylinder bore diameter	Cyl 1	Cyl 2	Cyl 3	Cyl 4	Cyl 5	Cyl 6
Тор	3.3303	3.3309	3.3303	3.3305	3.3305	3.3305
Bottom	3.3306	3.3309	3.3306	3.3312	3.3306	3.3309
Main bore (all ±0.000	5 in)	2.847 in				
Deckheight (all ±0.00	01 in)	7.391 in	D	eck Milled	0.04 in	
		Connecti	ng rods			. <u> </u>
Bore (all ± 0.0005 in)	2.12	25 in	Mass 4	140 g		
Length (all 0.0005 in) 5.7	in				
		Pisto	ns			
Diameter (all ± 0.001	in)		Ring land	clearance	(all ± 0.0005	in)
Top 3.3225 in			Тор	0.0022 in		
Middle 3.3241 in			Middle	0.0015 in		
Bottom 3.3264 in				•		
Mass 329 g			Piston He	eight 1.4	416 in	
		Piston	pins			
Pin to piston bore cle	arance (all ±	0.0003 in)	0.0008 in	Ma	ass 122 g	
		Piston	rings			
Gap (all ± 0.0005 in)						-
Top 0.0135 in			Mass 3	9 g	··· ·	
Middle 0.0085 in	····		Oil ring to	ension (pull)	11.5—12.	0 lbf
		Crank	shaft			
Rod journal (all ± 0.00	005 in) 1.9	983 in				
Main journal (all \pm 0.0	0005 in) 2.6	6468 in				
Stroke (all ± 0.0003 in) 3.3	31 in				
		Rod bea	arings			
Thickness (all ± 0.000	5 in)		Average	clearance	0.002 in	
Max 0.0622 in						
Min 0.0595 in			Mass 3	3 g		
		Main be	arings			
Thickness (all ± 0.000	5 in)		Average	clearance	0.002 in	
Max 0.0958 in			Min 0	.0929 in		

months when temperatures were below 7 to 10°C. Hence, starting involved cranking the engine for several minutes. During the long cranking times methanol was continuously injected into the cylinder and washed the lubricating oil from the cylinder walls. The oil sample analysis for the oil change after the winter months of mileage accumulation showed high engine wear.

Table 5. Short-Block Measurements After Mileage Accumulation

		Cylinde	r block			
Cylinder bore diameter	Cyl 1	Cyl 2	Cyl 3	Cyl 4	Cyl 5	Cyl 6
Тор	3.3315	3.3311	3 3313	3.3316	3.3315	3.3315
Bottom	3.3308	3.331	3.3313	3.3312	3.331	3.3312
Main bore (all ± 0.000	15 in)	2.847 in				
Deck height (all ± 0.00	01 in)	7.391 in	De	eck Milled	0.04 in	
		Connec	ting rods			
Bore (all ± 0.0005 in)	2.1	25 in	Mass 4	40 g		
Length (all ± 0.0005 in	n) 5.7	in				
		Pis	tons			
Diameter (all ± 0.001 in)			Ring land cl	earance (all	±0.0005 in)	
Top 3.3225 in			Тор	0.0022 in		
Middle 3.3241 in			Middle	0.0015 in		
Bottom 3.3264 in						
Mass 329 g			Piston He	ight 1.4	416 in	
		Pisto	n pins			
Pin to piston bore cle	arance (all ±	0.0003 in)	0.0008 in	Ma	ass 122 g	
		Pisto	n rings			
Gap (all ± 0.0005 in)						
Top 0.0155 in			Mass 3	9 g		
Middle 0.0105 in			Oil ring to	ension (pull)	11.5—12.	0 lbf
		Cran	kshaft			
Rod journal (all ± 0.00	005 in) 1.9	9983 in				
Main journal (all ± 0.0	0005 in) 2.6	3468 in				
Stroke (all ± 0.0003 in	n) 3.3	31 in				
		Rod b	earings			
Thickness (all ± 0.0005 i	n)		A /erage	clearance	0.002 in	
Max 0.0623 in			1			
Min 0.0598 in			Mass 3	3 g		
		Main b	earings			
Thickness (all ± 0.0005	in)		Average	clearance	0.002 in	
Max 0.0958 in			Min 0	.0929 in		

In addition to the cylinder wall, piston, and ring wear described above, the exhaust valve guides showed approximately 0.001 in wear, which is not considered excessive. The bearings showed normal wear other than the detonation-associated wear on the rod bearings in Cylinders 3, 4, and 5. Tables 4 and 5 present the detailed short-block measurements for before and after mileage accumulation, respectively. Similarly, Tables 6 and 7 present the cylinder head measurements. Oil sample analyses also

Cyl 1 Cyl 3 Cyl 5 Exhaust Intake **Exhaust** Intake **Exhaust** Intake 0.3131 0.3138 0.3139 0.3136 0.3138 0.3132 Valve stem dia (in) Valve dia (in) 0.315 0.3151 0.3151 0.3151 0.3149 0.3152 Installed height (in) 1.72 1.72 1.71 1.72 1.71 1.715 Shim thickness (in) 0.075 0.075 0.06 0.075 0.06 0.075 Spring coil bind (in) 1.19 1.19 1.19 1.19 1.19 1.19 Spring pressure (lbf) 95 95 95 95 95 95 Retainer to seal (in) 0.54 0.54 0.54 0.54 0.54 0.54 Seal thickness (in) 0.16 0.16 0.16 0.16 0.16 0.16 Comb chamber (cc) 26.6 26.6 26.6 26.6 26.6 26.6 Cyl 2 Cyl 4 Cyl 6 Exhaust Intake **Exhaust** Intake **Exhaust** Intake Valve stem dia (in) 0.3135 0.3137 0.3138 0.3138 0.3138 0.3138 Valve dia (in) 0.3152 0.3152 0.3151 0.315 0.315 0.315 1.72 1.715 Installed height (in) 1.73 1.725 1.715 1.715 0.075 0.075 0.075 0.06 0.075 Shim thickness (in) 0.075 Spring coil bind (in) 1.19 1.19 1.19 1.19 1.19 1.19 95 95 Spring pressure (lbf) 95 95 95 95 0.54 0.54 0.54 0.54 0.54 Retainer to seal (in) 0.54 Seal thickness (in) 0.16 0.16 0.16 0.16 0.16 0.16 Comb chamber (cc) 26.6 26.6 27.2 26.6 26.8 26.6 Gasket surface milled (in) 0.04 Head gasket thickness (in) 0.068 472.38 Head gasket volume (cc) 11.56 Total swept volume (cc) 11.72

Table 6. Cylinder Head Measurements Before Mileage Accumulation

indicated high upper-cylinder wear. Oil sample analysis sheets are included in Appendix B.

Several oil leaks were noted around gaskets and seals. Figure 9 shows one such oil leak on the rear of the cylinder block. Perhaps the blowby of methanol into the crankcase during cold starting affected the gaskets and seals. All gaskets and seals have been sent to FEL-PRO for further analysis.

The detonation is thought to have been caused by injector wear. If the injectors experienced wear due to the low lubricity of methanol, they could have provided poor atomization of the fuel and/or too little fuel to some cylinders. Either condition could have provided an effectively lean mixture for some cylinders and thus promoted detonation in those cylinders. A visual inspection of the fuel injectors indicated that the injector for Cylinder 4 contained some foreign material in its exit. The injectors have been sent to SwRI for further testing and evaluation.

Compression ratio

Cyl 1 Cyl 3 Cyl 5 **Exhaust** Intake Exhaus: Intake **Exhaust** Intake 0.3139 0.3135 0.3138 Valve stem dia (in) 0.3131 0.3129 0.3138 0.3135 0.3136 0.3134 0.3137 0.3132 0.3129 0.3155 0.3155 0.3151 0.3155 0.3152 0.3168 0.3155 0.3158 0.3152 0.3152 0.315 0.3152 Valve dia (in) 1.72 1.72 1.71 1.72 1.71 1.715 Installed height (in) Shim thickness (in) 0.075 0.075 0.06 0.075 0.06 0.075 Spring coil bind (in) 1.19 1.19 1.19 1.19 1.19 1.19 95 95 Spring pressure (1bf) 95 95 95 95 Retainer to seal (in) 0.54 0.54 0.54 0.54 0.54 0.54 Seal thickness (in) 0.16 0.16 0.16 0.16 0.16 0.16 Comb chamber (cc) 26.6 26.6 26.6 26.6 26.6 26.6 Cyl 2 Cvl 4 Cyl 6 Exhaust Exhaust Exhaust Intake 0.3138 0.3135 0.3134 0.3136 0.3137 0 3135 0.3138 0.3132 0.3138 0.03136 0.3137 0.3134 Valve stem dia (in) 0.3168 0.3152 0.3156 0 3155 0.316 0.315 0.3155 0.3151 0.3155 Valve dia (in) 0.3153 0.315 0.3151 Installed height (in) 1.73 1.725 1.72 1.715 1.715 1.715 0.075 0.075 0.075 0.075 Shim thickness (in) 0.075 0.06 Spring coil bind (in) 1.19 1.19 1.19 1.19 1.19 1.19 Spring pressure (lbf) 95 95 95 95 95 95 0.54 Retainer to seal (in) 0.54 0.54 0.54 0.54 0.54 Seal thickness (in) 0.16 0.16 0.16 0.16 0.16 0.16 Comb chamber (cc) 26.6 26.6 27.2 26.6 26.8 26.6 Gasket surface milled (in) 0.04 Head gasket thickness (in) 0.068 Total swept volume (cc) 472,38 11.56 Head gasket volume (cc) Compression ratio 11.72

Table 7. Cylinder Head Measurements After Mileage Accumulation

6. Engine Performance

Engine performance at peak load was determined on a SuperFlow dynamometer before the engine was installed in the vehicle and again at the end of the mileage accumulation and after the final emissions and oil consumption tests were completed. Figures 10, 11 and 12 show the engine as mounted on the SuperFlow dynamometer. Corrected torque and power curves for the before and after tests are presented in Figures 13 and 14. Data from two runs during each test session on the dynamometer are shown. The low torque reading for one of the initial runs at 3750 rpm is due to fuel calibration. The calibration was adjusted and the curve smoothed, as the other initial data point for 3750 rpm indicates.

During the initial dynamometer tests the engine produced a maximum torque of 201 lbf-ft at 3750 rpm and a maximum power of approximately 161.5 hp at 5000 rpm. The end of project tests show maximum torque and power outputs of 192.4 lbf-ft at 4000 rpm and 155.4 hp at 5000 rpm. GM advertised the torque and power output of the stock 2.8-L engine on gasoline (with accessories) as 160 lbf-ft at 3600 rpm and 125 hp at 4500 rpm. These points are shown on the curves for reference. The engine showed

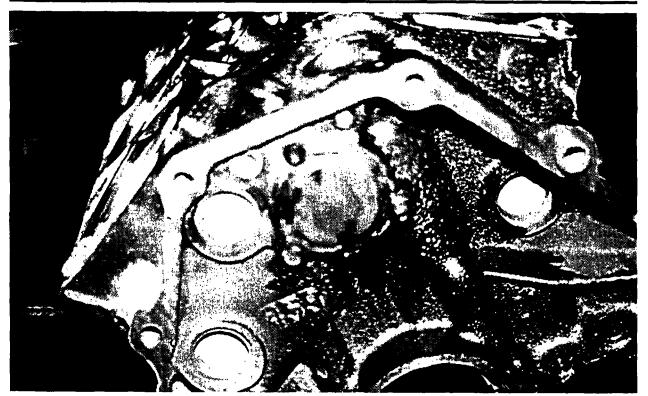


Figure 9. Rear of cylinder block showing oil leak

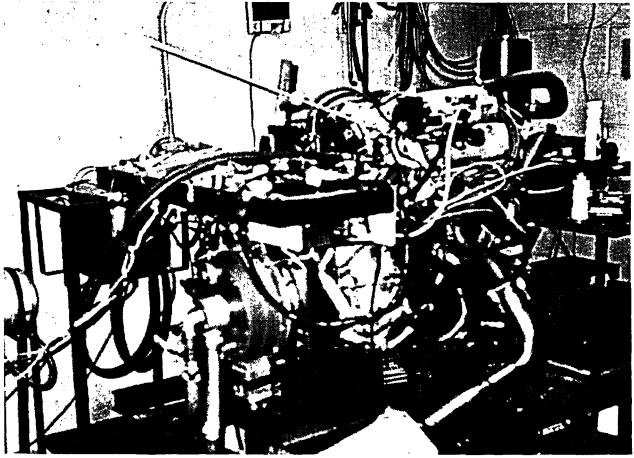


Figure 10. Engine mounted on SuperFlow dynamometer

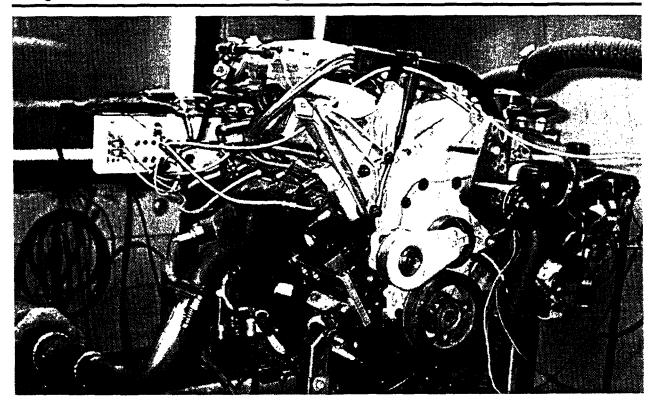


Figure 11. Engine mounted on SuperFlow dynamometer

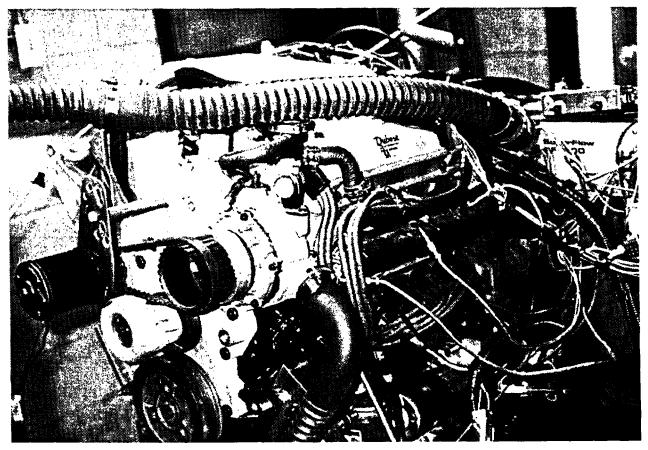


Figure 12. Engine mounted on SuperFlow dynamometer

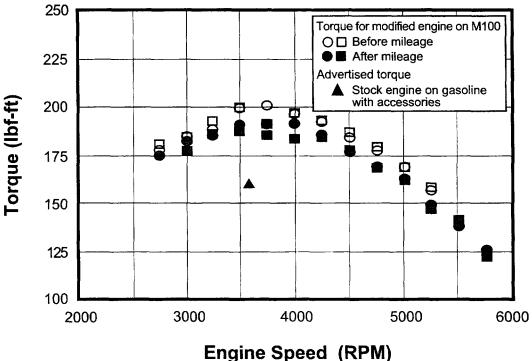


Figure 13. Engine torque output

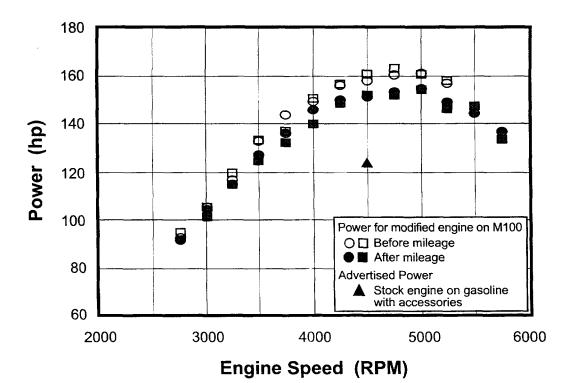


Figure 14. Engine power output



Figure 15. Vehicle during emissions tests at Southwest Research Institute

a decrease in maximum torque of about 4.3% and a decrease in maximum power of about 3.8% between the initial tests and the final tests. This amount of decrease is not considered unusual for 22,000 miles of operation; however, as was noted above, the engine suffered significant degradation in one cylinder.

7. Emissions And Fuel Economy

The vehicle was driven to SwRI in San Antonio, Texas, for full Environmental Protection Agency (EPA) FTP emissions testing at the beginning and completion of the program. Figure 15 depicts the vehicle during testing at SwRI. The emission test results at program initiation were very encouraging, with the vehicle meeting ultra-low emissions vehicle (ULEV) standards for all components except non-methane organic gases (NMOG). The pre- and post-test NMOG values are uncorrected since a reactivity adjustment factor (RAF) for M100 could not be obtained. Test results at program completion showed increased emissions for all exhaust components for all bags during the FTP testing, except non-methane hydrocarbons (NMHC). Emission results are given in Table 8. The SwRI reports are included in Appendix C.

The poorer emissions results during the second test are thought to have resulted from unburned fuel/air mixture that escaped the combustion process as a result of the scored

SwRI Test Jan. 1993 SwRi Test Dec. 1994 ULEV Constituent (gm/mi) (gm/mi) (grm/mi) 1. THC 0.48 1.167 2. CO 4.280 1.700 0.960 3. NO_x 0.200 0.150 0.690 4. CH₄ 0.035 0.193 5. NMHC 0.011 0.004 6. Carbonyl 0.005 0.022 7. Alcohol 0.464 0.948 8. NMOG 0.479* 0.975* 0.040 0.008 9. Formaldehyde 0.0030 0.0200 10. Acetaldhyde 0.0002 0.0007 11. Acrolein 0.0000 0.0000 12. Acetone 0.0007 0.0012 13. Propionald 0.0000 0.0002 14. Crotonald 0.0000 0.0000 15. Isobutyr+MEK 0.00018 0.00064 16. Benzaldehyde 0.0000 0.0000 17. 0.0000 0.0000

Table 8. Vehicle Emissions Results

0.4640

0.0000

Hexanalde

hyde 18. Methanol

19. Ethanol

and scuffed cylinder wall and top piston ring in Cylinder 4. Lubricating oil left on the cylinder wall also undoubtedly contributed to the increased emissions. Incomplete combustion and detonation are also thought to have occurred in this cylinder as evidenced by the damaged spark plug and combustion product contamination. The pistons from Cylinders 3 and 5 also showed evidence of leakage past the top ring, which also contributed to increased emissions. To determine whether degraded catalyst performance also contributed to the increased emissions, the catalyst was removed from the vehicle and sent to Allied-Signal for analysis. At the time that this report was prepared, Allied-Signal had not completed their evaluation.

0.9470

0.0000

Fuel economy was measured during the FTP tests and highway economy was estimated during trips to and from San Antonio. FTP city mileage was measured to be 9.91 mpg (19 mpeg) during initial testing in January 1993 and 9.73 mpg (18.65 mpeg) during final testing in December 1994. This corresponds to a change of -1.8%. Highway mileage was estimated to be 16 mpg (31 mpeg). The highway fuel economy rating for the stock gasoline vehicle was 29 mpg. The relatively small change in city fuel economy could be due to test variability only and could have nothing to do with vehicle

^{*} The RAF for M100 was unknown; thus, this value is uncorrected.

performance. No changes were made to the fuel-management control system during the program, and the O₂ exhaust sensor appeared to be operating properly during engine dynamometer testing; thus, if the vehicle fuel economy was actually reduced it was probably due to the degraded performance of Cylinder 4. Visual examination of the Cylinder 4 injector disclosed some discoloration and contaminate buildup, which may also have been due to the abnormal combustion process in this cylinder.

8. Oil Consumption Testing

The vehicle underwent initial oil consumption testing at SwRI in San Antonio. Initial tests were completed during March 1993 when the engine had logged about 1,500 miles. Additional oil consumption tests were completed during early 1995 after the vehicle had accumulated approximately 22,000 on-road miles. The SwRI oil consumption test reports are included in Appendices D and C. The initial test results reflect an oil consumption rate that is somewhat higher than typical gasoline-fueled vehicles that have been tested by SwRI. Data presented by Manni and Ciocci [3] also indicate that the initial oil consumption rate may have been higher than typical for gasoline fueled engines, especially at low engine speed. However, some of the data presented by Manni and Ciocci indicate oil consumption rates higher than those produced during the initial tests on the Corsica. In addition Roberts [4] presents results from an Exxon test that correlate well with the initial Corsica test results. Thus, although the initial oil consumption results for the M100-fueled Corsica may be on the high end of the range for typical gasoline engines, the oil consumption was not exceptionally high. The initial oil consumption rate may have been affected by the lack of engine operating time before the test. The excellent results achieved during the emissions testing in January 1993 would reasonably have been expected to correlate with low oil consumption.

It was noted that there appeared to be a relationship between engine deceleration and increased oil consumption during the tests. The amount of valve lubricating oil drawn into the intake manifold may have increased with the greater manifold vacuum during deceleration. The SwRI report mentioned a relationship between high-temperature engine operation and increased oil consumption. Roberts [4] indicates that oil consumption is strongly related to both oil viscosity and oil volatility. Lower oil viscosity and higher oil volatility both promote higher oil consumption. The test oil used by SwRI was a 10W-30-grade oil with a viscosity of 9.85 cS at 100°C. This value of 100°C viscosity is on the lower end of the viscosity range of the oils used in the tests reported by Roberts [4].

The oil consumption tests run after the mileage accumulation showed significant increases in the oil consumption rates. Table 9 presents a summary comparison of the results from the two tests. The largest increase in the oil consumption rate was 123.6%,

which was observed during steady-state operation at 2675 rpm. The increased oil consumption was almost certainly caused by the excessive scuffing and wear in Cylinder 4 and to a lesser extent by the wear in Cylinders 3 and 5. Moderate wear of the exhaust valve guides was noted earlier; however, there was no indication that the valve guide seals had deteriorated. Even the highest oil consumption rate reported by SwRI for the Corsica was only about 9% greater than oil consumption rates reported in reference [3] for gasoline engines. The condition of the engine at tear-down would indicate that the oil consumption should be even higher.

9. Conclusions

Long-term testing of the M100-fueled 1988 Corsica confirmed several reasonably well understood conditions and disclosed a few anomalies that may warrant further study. These are listed below:

- A. It seems apparent that no off-the-shelf fuel pump is available that will provide reliable long-term service in M100. The problems appear to be primarily related to materials incompatibility with the fuel, but the lack of lubricity of M100 may also be factor contributing to fuel pump component wear. This lack of lubricity may have also been a factor in the (apparent) degraded performance of the injectors, which is thought to have led to detonation in Cylinders 3, 4, and 5. If M100 is to continue to be considered as an alternative fuel for the future, this problem needs to be investigated thoroughly.
- B. Cold-starting is a severe problem when using M100 as a fuel below ambient temperatures of 15°C. Cold cranking of the Corsica is thought to have led to the degraded condition in Cylinders 3, 4, and 5, which contributed to combustion product buildup between the first and second piston rings in these cylinders and scoring of the cylinder wall and piston scuffing in Cylinder 4. An effective solution for this problem must be identified if M100 is to be a viable alternative fuel.
- C. The results of the FTP emissions test at program initiation were excellent, with all exhaust constituents below ULEV levels except NMOG. Emissions at program conclusion were increased significantly as a result of the degraded condition of Cylinders 3, 4, and 5. Catalyst poisoning due to increased lubricating oil consumption may also have been a contributing factor. Allied Signal has agreed to evaluate the catalyst condition. The results of this evaluation will be forwarded to NREL when received.
- D. Based on the results of this research, M100 is considered to have excellent potential as an alternative fuel. Cold-starting problems and component wear due to lack of lubricity will have to solved, but M100 has the potential for excellent emissions and, with a properly designed engine, provides outstand-

- ing vehicle performance and fuel economy. No fuel safety or handling problems were encountered during the project. The one case of fuel degradation (one 55-gallon drum) is thought to have been related to long-term storage in relatively poor environmental conditions. No other fuel quality problems were encountered during the project.
- E. The initial oil consumption rates measured for the M100-fueled engine are on the upper end of the range typical of gasoline-fueled engines. The wear and damage experienced by the engine significantly affected the increase in the oil consumption rate.

10 References

- 1. Truman, R., D. Bretherton, B. Smith, R. Taeuber, M. Walser, and J. Jones, Texas Tech 1989 SAE Methanol Marathon Entry, 1989.
- 2. Walser, M., R. Taeuber, G. Bourn, M. Kasik, J. Jones, and T. Maxwell, Texas Tech 1990 SAE Methanol Challenge Entry, 1990.
- 3. Manni, M. and G. Ciocci, An Experimental Study of Oil Consumption in Gasoline Engines, SAE Paper No. 922374.
- 4. Roberts, D. C., Section 4.7 Review of Oil Consumption Aspects of Engines, Engine Oils and Automotive Lubrication, edited by Wilfried J. Bartz, Marcel Dekker, Inc., New York, 1993.

APPENDIX A ECM Calibration Tables

Table F1 Main Spark Advance vs. LV8 - Load Conversion Equation N = E * 256 / 90

	400 rpm		1	600 rpm		T	800 rpm			1000 rpm		1	1200 rpm	
16 BK	Decimal	Engineering	16 Bit	Decimal	Engineering	16 Bit	Decimal	Engineering	16 Bit	Decimel	Engineering	16 Bit	Decimal	Engineering
Heddeolmei	Computer	Unit	Hexideolmei	Computer	Unit	Hexidecimal	Computer	Unit	Hexidecimal	Computer	Unit	Hexidecimal	Computer	Unit
Address	Unit	(deg.)	Address	Unit	(deg.)	Address	Unik	(deg.)	Address	Unit	(deg.)	Address	Unit	(deg.)
8011	63	22	801D	63	22	8029	63	22	8035	63	22	8041	63	22
8012	63	22	601E	63	22	802A	63	22	8036	63	22	8042	63	22
8013	63	22	801F	63	22	802B	63	22	8037	63	22	8043	63	22
8014	63	22	5020	63	22	802C	63	22	8038	63	22	8044	63	22
8015	63	22	8021	63	22	802D	63	22	8039	63	22	8045	63	22
8016	67	20	8022	57	20	802E	57	20	803A	5 7	20	8046	57	20
8017	51	18	8023	51	18	802F	51	18	803B	51	18	8047	51	18
8018	51	18	8024	51	18	8030	51	18	803C	51	18	8048	51	18
8019	61	18	8025	51	18	8031	61	18	803D	51	18	8049	51	18
801A	48	17	8026	48	17	8032	48	17	803E	48	17	804A	51	18
6 01B	43	16	8027	43	15	8033	43	15	803F	43	15	804B	46	16
801C	34	12	8028	34	12	8034	34	12	8040	34	12	804C	34	12
	1400 rpm			1600 rpm			1800 rpm			2000 rpm			2200 rpm	
16 BR	Decimal	Engineering	16 Bit	Decimal	Engineering	16 BH	Decimal	Engineering	16 BH	Decimal	Engineering	16 BH	Decimel	Engineering
Heddeolmel	Computer	Unit	Hexidecimal	Computer	Unit	Hexidecimal	Computer	Unit [Hexidecimal	Computer	Unit	Hexidecimal	Computer	Unit
Address	Unit	(deg.)	Address	Unit	(deg.)	Address	Unit	(deg.)	Address	Unit	(deg.)	Address	Unit	(deg.)
804D	65	23	8059	77	27	8065	77	27	8071	80	28	90 7D	80	26
804E	66	23	805A	80	28	8066	85	30	8072	91	32	807E	91	32
804F	66	23	805B	80	28	8087	85	30	8073	91	32	807F	9 1	322
8050	65	23	806C	80	26	8068	85	30	8074	91	32	8080	91	322
8051	66	23	806D	80	26	8069	85	30	8075	91	32	8061	91	322
8052	65	23	805E	80	26	808A	85	30	8076	91	32	8082	91	32
8068	65	23	806F	80	26	6068	82	29	8077	88	31	8083	91	32
8054	66	23	8060	80	26	806C	80	28	8078	85	30	8084	88	31
8066	66	23	8061	71	25	606D	74	26	8079	74	26	8085	80	26
8056	57	20	8082	65	23	806E	65	23	807A	65 (66)	23 (24)	8086	71	25
8057	48	16	8063	67	20	806F	57	20	807B	54 (60)	19 (21)	8067	54 (65)	19 (23)
8058	37	13	8064	41	14.4	8070	43	15	807C	40 (49)	14 (17.2)	8068	40 (52)	14 (18.3)

^() Designates Original Value

Table F1 Main Spark Advance vs. LVS - Load (Continued)

	2400 rpm			2800 rpm			3200 rpm			3600 rpm			4000 rpm	
16 BK	Decimal	Engineering	16 Bit	Decimal	Engineering	16 Bit	Decimal	Engineering	16 Bit	Decimal	Engineering	16 Bit	Decimal	Engineering
Herddeolmal	Computer	Unit	Hexideoimal	Computer	Unit	Hexidecimal	Computer	Unit	Hexidecimal	Computer	Unit	Hexideolmel	Computer	Unit
Address	Unit	(deg.)	Address	Unit	(deg.)	Address	Unit	(deg.)	Address	Unit	(deg.)	Address	Unit	(deg.)
8089	93	32.7	8095	86	30	80A1	85	30	80AD	85	30	8089	85	30
BOBA	91	32	8098	94	33	80A2	94	33	80AE	91	32	80BA	91	32
8006	94	33	8097	94	33	80A3	94	33	80AF	91	32	8088	91	32
808C	94	33	9098	94	33	80A4	94	33	60B0	88	31	808C	85	30
8060	94	33	8099	94	33	80A5	88	31	80B1	86	30	60B D	82	29
806E	91	32	809A	91	32	80A6	88	31	60B2	82	29	60BE	82	29
606F	90	31.6	809B	66	31	80A7	85	30	80B3	82	29	BOBF	82	29
8090	66	31	809C	88	31	80A8	65	30	80B4	82	29	8000	82	29
8091	85	30 .	809D	85	30	80A9	82	29	80B5	80	26	80C1	82	29
8092	74	26	809E	74	26	BOAA	74	26	8088	74	26	80C2	80	26
8093	57 (65)	20 (23)	BOOF	57 (65)	20 (23)	BOAB	63 (66)	22 (24)	8087	65 (71)	23 (26)	80C3	68 (74)	24 (26)
8094	49 (57)	17.2 (20)	80A0	48 (66)	17 (19.7)	80AC	51 (50)	18 (19.7)	8088	50 (53)	17.5 (18.6)	80C4	51 (56)	18 (19.7)
	4400 rpm			4800 rpm										1
16 BK	Decimal	Engineering	16 BH	Decimal	Engineering	ļ	LV8 - Load							j
Heddeoimel	Computer	Unit	Hexideolmei	Computer	Unit	ŀ	(for each							1
Address	Unit	(deg.)	Address	Unit	(deg.)	Ĺ	series)	1	Main Spark Ti	ming Calou	iation			
80C5	86	30	80D1	86	30		32							ı
8006	91	32	8002	91	32	İ	48	1	Sperk Advenor				-	
8007	91	32	8003	91	32	1	64		(deg. BTC)	< Ta	ble F1>	< Table F	2 >	
80C8	9 1	32	80D4	88	31	1	∞							1
8009	86	30	8005	85	30		96							1
BOCA	82	29	80D6	85	3 0		112							1
80CB	82	29	80D7	85	30	[126	8	Spark Timing R	lange la 60 d	leg. BTC to 10	deg. ATC		
80CC	82	29	80D8	85	30	1	144							1
8000	82	29	80D9	77	27	1	160	F	Reference Pula	e at 60 deg.	BTC			1
BOCE	80	28	80DA	68	24	- 1	176							I
BOOF	66 (74)	24 (26)	80DB	63 (68)	22 (24)	Ī	192							
8000	54 (60)	19 (21)	80DC	60 (66)	21 (23.2)		208							

^() Designates Original Value

Table P2 Base Coolant Advance Correction vs. LV8 - Load Conversion Equation N = (E + KCTBIAS)*256/90

-16	deg. C		4	deg. C		8	deg. C		20	deg. C		32	deg. C	
16 BK	Decimal	Engineering		Decimal	Engineering	16 Bit	Decimal	Engineering	16 BH	Deolmei	Engineering	16 Bit	Decimal	Engineering
Handdeolmel	Computer	Unit	Hexidecimal	Computer	Unit	Hexideolmel	Computer	Unit	Hexidecimal	Computer	Unit	Hexidecimal	Computer	Unit
Address	Unit	(deg.)	Address	Unit	(deg.)	Address	Unit	(deg.)	Address	Unit	(deg.)	Address	Unit	(deg.)
80EA	111	4	80F3	111	4	80FC	105	1.8	8105	83	-6	810E	89	-4
BOEB	111	4	80F4	111	4	80FD	106	1.6	8106	83	-6	810F	69	-4
80EC	111	4	80F5	111	4	80FE	105	1.8	8107	83	-6	8110	89	-4
BOED	111	4	80F6	111	4	80FF	105	1.8	8108	83	-6	8111	89	-4
SOEE	111	4	60F7	111	4	8100	106	1.8	8109	100	0	8112	100	0
80EF	114	6	80F8	114	5	8101	108	2.8	810A	100	0	8113	100	0
80F0	117	6	80F9	117	6	8102	111	4	810B	111	4	8114	105	1.8
80F1	119	6.7	80FA	119	6.7	8103	114	5	810C	114	5	8115	106	2.8
90E3	122	7.7	80FB	122	7.7	8104	117	6	810D	117	в	8116	111	4
44	deg. C		56	deg. C			deg. C		80	deg. C			deg C	
16 BK	Decimal	Engineering	16 BH	Decimal	Engineering	16 BH	Decimal	Engineering	16 BK	Decimal	Engineering	16 Bit	Decimal	Engineering
Heddeome	Computer	Unit	Hexideolmai	Computer	Unit	Hexidecimal	Computer	Unit	Hexidecimal	Computer	Unit	Hexidecimal	Computer	Unit
Address	Unit	(deg.)	Address	Unit	(deg.)	Address	Unit	(deg.)	Address	Unit	(deg.)	Address	Unit	(deg.)
8117	89	-4	8120	94	-2	812 9	100	0	8132	100	0	813B	100	0
8118	89	-4	6121	94	-2	812A	100	0]	8133	100	0	813C	100	0
8119	89	-4	8122	94	-2	812B	100	0	8134	100	0	613D	100	0
611A	89	-4	8123	94	-2	812C	100	0	8135	100	0	813E	100	٥
8118	100	0	8124	100	0	812D	100	0	8136	100	0	813F	100	0
811C	100	0	8125	100	0	812E	100	0	8137	100	0	8140	100	0
811D	102	0.7	8126	100	0	812F	100	0	813 8	100	0	8141	100	0
811E	102	0.7	8127	102	0.7	8130	100	0	8139	100	0	8142	100	0
811F	108	2.8	8128	106	1.8	8131	100	0	613A	100	0	8143	100	<u> </u>
	deg. C			deg. C		-								
16 BK	Decimal	Engineering	16 Bit	Decimal	Engineering	ŀ	LV8 -Load							•
Heddeolmal	Computer	Unit (Hexideolmel	Computer	Unit	[(for each	•	Main Spark Ti	ming Calcul	lation			I
Address	Unit	(deg.)	Address	Unit	(deg.)	_	peries)							Į.
8144	100	0	814D	100	0	1	0			•		+ Coolant Tim		- [
8145	100	0	814E	100	0	- [32		(deg. BTC)	< 18	ble F1>	< Table F	2 >	1
6146	100	0	814F	100	0		64							į.
8147	100	0	8150	100	•	}	96	_		D. 5	Mar4.01 -	A T 4 A A		í
8148	100	0	8151	100	0	1	128		coolant Timing	Blas : Func	tion of Coolean	t Temp. and M	IAP"	
8149	100	0	8152	100	0	j	160							j
814A	100	0	6153	94	-2	- 1	192							ì
8148	94	-2	8164	91	-9	1	224							j
814C	94	-2					256							

Table F200 Ct. (Open Loop) Base Pulse Inject vs. LV8 - Load and RPM Conversion Equation $N=E^+66.636/6$

	0 rpm			400 rpm		1	800 rpm			1200 rpm			1600 rpn	1
16 BK	Decimal	Engineering	16 BH	Decimal	Engineering	16 Bit	Decimal	Engineering	16 Bit	Decimel	Engineering	16 Bit	Decimal	Engineeri
Haddeolmel	Computer	Unit	Hexideolma		Unit	Hexidecimal			Hexidecima	i Computer	Unit	Hexidecima	Compute	r Unit
Address	Unit	(deg.)	Address	Unit	(msec.)	Address	Unit	(meec.)	Address	Unit	(meec.)	Address	Unit	(meec.)
8615	0	0	8826	0	0	8837	0	0	8848	0	0	8659	0	0
8616	Ø (13)	0.69 (1.0)	8827	9 (13)	0.69 (1.0)	8638	9 (13)	0.69 (1.0)	8849	9 (13)	0.69 (1.0)	885A	9 (13)	0.69 (1.0
8617	16 (28)	1.22 (2.1)	8828	16 (26)	1.22 (2.1)	8839	16 (26)	1.22 (2.1)	884A	16 (26)	1.22 (2.1)	885B	16 (28)	1.22 (2.1
8616	22 (45)	1.66 (3.4)	8829	22 (45)	1.68 (3.4)	883A	22 (45)	1.68 (3.4)	864B	22 (45)	1.68 (3.4)	885C	22 (45)	1.66 (3.4)
8619	49 (61)	3.74 (4.66)	882A	49 (61)	3.74 (4.65)	883B	49 (61)	3.74 (4.65)	884C	49 (61)	3.74 (4.65)	885D	49 (61)	3.74 (4.65
861A	67 (77)	5.11 (6.9)	882B	67 (77)	5.11 (5.9)	883C	67 (77)	5.11 (5.9)	884D	67 (77)	5.11 (5.9)	885E	67 (77)	5.11 (5.9)
861B	81 (94)	6.18 (7.2)	882C	81 (94)	6.18 (7.2)	883D	81 (94)	6.18 (7.2)	884E	81 (94)	6.18 (7.2)	885F	81 (94)	6.18 (7.2)
861C	105 (110)	8.01 (8.4)	8820	106 (110)	8.01 (8.4)	683E	105 (110)		884F	106 (110)	8.01 (8.4)	8660	106 (110)	8.01 (8.4)
861D	116 (125)	9.0 (9.6)	882E	118 (125)	9.0 (9.5)	683F	118 (125)	9.0 (9.5)	8850	118 (125)	9.0 (9.5)	8861	118 (125)	9.0 (9.5)
861E	133 (141)	10.15 (10.8)	882F	133 (141)	10.15 (10.8)	8640	133 (141)	10.15 (10.8)	8851	133 (141)	10.15 (10.8)	8862	133 (141)	10.15 (10.8
881F	155 (157)	11.83 (12)	8830	155 (157)	11.83 (12)	8641	155 (157)	11.83 (12)	8852	156 (157)	11.83 (12)	8863	155 (157)	11.63 (12)
8620	170 (172)	12.97 (13.1)	8631	170 (172)	12.97 (13.1)	8842	170 (172)	12.97 (13.1)	8853	170 (172)	12.97 (13.1)	8664	170 (172)	12.97 (13 1
8621	188	14.34	8832	188	14.34	8849	186	14.34	8854	188	14.34	8865	188	14.34
8622	204	15.6	8833	204	15.6	8844	204	15.6	8855	204	15.6	8866	204	15.6
8023	219	16.7	8834	219	16.7	8845	219	16.7	8856	219	16.7	6867	219	16.7
8624	236	17.9	8835	236	17.9	8846	235	17.9	8857	235	17.9	8868	235	17.9
8825	251	19.15	8836	251	19.15	8847	251	19.15	8858	261	19.15	8869	261	19.15
	2000 rpm			2400 rpm			2800 rpm			3200 rpm			3600 rpm	
16 BK	Decimal	Engineering	16 Bit	Decimal	Engineering	16 BH	Decimal	Engineering	16 BH	Decimal	Engineering	16 BK	Decimal	Engineering
Herddeolmel	Computer	Unit	Hexidecimal	Computer	Unit	Hexidecimal	Computer	Unit	Hexidecimal	Computer		Hexidecimal	Computer	Unit
Address	Unit	(meec.)	Address	Unit	(meec.)	Address	Unit	(meec.)	Address	Unit	(meec.)	Address	Unit	(meec.)
886A	0	0	887B	0	0	868C	0	0	0988	0	0	88AE	0	0
8068	9 (13)	0.89 (1.0)	887C	9 (13)	0.69 (1.0)	888D	9 (13)	0.69 (1.0)	889E	9 (13)	0.69 (1.0)	88AF	9 (13)	0.69 (1.0)
886C	16 (26)	1.22 (2.1)	867D	16 (26)	1.22 (2.1)	888E	16 (26)	1.22 (2.1)	889F	16 (26)	1.22 (2.1)	88B0	16 (26)	1.22 (2.1)
886D	22 (45)	1.68 (3.4)	887E	22 (45)	1.68 (3.4)	888F	22 (45)	1.68 (3.4)	68A0	22 (45)	1.68 (3.4)	88B1	22 (45)	1.68 (3.4)
806E	49 (61)	3.74 (4.65)	887F	49 (61)	3.74 (4.66)	8890	49 (61)	3.74 (4.65)	88A1	49 (61)	3.74 (4.65)	8882	49 (61)	3.74 (4.65)
886F	67 (77)	5.11 (5.9)	8880	67 (77)	5.11 (5.9)	8891	67 (77)	5.11 (5.9)	88A2	67 (77)	5.11 (5.9)	88 83	67 (77)	5.11 (5.9)
8670	81 (94)	6.18 (7.2)	8881	81 (94)	6.18 (7.2)	8892	81 (94)	6.18 (7.2)	88A3	81 (94)	6.18 (7.2)	88B4	81 (94)	6.18 (7.2)
8671	105 (110)	8.01 (6.4)	6662	106 (110)	8.01 (8.4)	8893	106 (110)	8.01 (8.4)	88A4	105 (110)	8.01 (8.4)	88B6	105 (110)	8.01 (8.4)
6672	118 (126)	9.0 (9.5)	8883	118 (125)	9.0 (9.5)	8894	118 (125)	9.0 (9.5)	88A6	118 (125)	9.0 (9.6)	88B6	118 (125)	9.0 (9.5)
8673	133 (141)	10.15 (10.8)	8884	133 (141)	10.15 (10.8)	8895	133 (141)	10.15 (10.8)	88A6	133 (141)	10.15 (10.8)	88B7	133 (141)	10.15 (10 8)
8674	155 (157)	11.63 (12)	8885	155 (157)	11.89 (12)	8896	165 (157)	11.83 (12)	88A7	155 (157)	11.83 (12)	8888	155 (157)	11 89 (12)
9676	170 (172)	12.97 (13.1)	6886	170 (172)	12.97 (13.1)	8897	170 (172)	12.97 (13.1)	88A8	• •	12.97 (13.1)	88B9	170 (172)	12.97 (13.1)
8676	186	14.34	8887	188	14.34	8898	188	14.34	8649	188	14.34	88BA	188	14.34
8677	204	15.6	8888	204	15.6	8899	204	15.6	88	204	15.6	66BB	204	15.6
8678	219	16.7	8889	219	16.7	889A	219	16.7	88AB	219	16.7	88BC	219	16.7
8679	235	17.9	888A	235	17.9	889B	235	17.9	88AC	235	17.9	88BD	235	17.0
867A	251	19.15	888B	251	19.15	589C	251	19.15	88AD	251	19.15	88BE	251	19.15

Table F200 CL (Closed Loop) Base Pulse Inject vs. LV8 - Load Conversion Equation N = E * 65.536 / 5

	0 rpm			
16 Bit	Decimal	Engineering	LV8	
Heddeoimei	Computer	Unit	Load	
Address	Unit	(meec.)		Base Injection Pulse Width Calculation
8815	0	0	0	
8816	9 (13)	0.69 (1.0)	16	BINJ PW Table Value * [(A/F)closed loop / (A/F)desired)]
8817	16 (28)	1.22 (2.1)	32	(Total PW/2) < Table F200 OL> < Table F50 >
8818	22 (45)	1.68 (3.4)	48	or
8819	49 (61)	3.74 (4.65)	64	<teble cl="" f200=""></teble>
881A	67 (77)	5.11 (5.9)	80	
8818	81 (94)	6.18 (7.2)	96	
861C	105 (110)	8.01 (8.4)	112	(A/F)closed loop / (A/F)desired >= 1
881D	118 (125)	9.0 (9.5)	128	
881E	133 (141)	10.15 (10.8)	144	Simultaneous Double Fire Injection: 1 Injection / Crankshaft Revolution
881F	155 (157)	11.83 (12)	160	
8820	170 (172)	12.97 (13.1)	176	Delivered PW = BINJ [Adeptive Mode * Decei Mode + Accel Mult.] + CL Corr + Inj Corr
8821	188	14.34	192	
8822	204	15.6	208	
8823	219	16.7	224	
8824	235	17.9	240	
6825	261	19.15	256	

Table F91 LV9 -Load Assel Enrichment Multiplier vs. Coolant Temp

Conversion Equation N = E * 128

16 BH	Decimal	Engineering	Coolant	
Hexideoimei	Computer	Unit	Temperature	
Address	Unit	(% Chng.)	deg. C	Acceleration Enrichment Multiplier Calculation
876C	245 (96)	1.92 (0.75)	-40	
876D	245 (92)	1.92 (0.72)	-25	Delivered PW = BINJ [Adeptive Mode * Decei Mode + Accel Mult.] + CL Corr + Inj Corr
876E	235 (88)	1.84 (0.89)	-16	- BPINJ
876F	191 (72)	1.49 (0.56)	-4	
8770	170 (64)	1.33 (0.5)	8	BPINJ - BPINJ + (BPINJ) (AE FACTOR)
8771	150 (56)	1.17 (0.44)	20	
8772	110 (40)	0.88 (0.31)	32	AE FACTOR = { (Load AE Mult. + Delta Throttle Poe. AE Mult.) - Limit } - Decay Rate
8773	96 (36)	0.77 (0.26)	44	< Table F91 > < Table F102>
8774	85 (32)	0.664 (0.25)	56	
8778	45 (16)	0.35 (0.125)	68	
8776	42 (16)	0.33 (0.125)	80	Additional fuel delivered 'synchronously' with base PW - based on rapid changes in
8777	18 (8)	0.14 (0.06)	92	measured etr/cytinder
6778	18 (8)	0.14 (0.06)	104	
8779	18 (8)	0.14 (0.08)	116	
877A	18 (8)	0.14 (0.06)	128	

Table F102 Delta Throttle Accel Enrichment Multiplier vs. Coclant Temp

Conversion Equation N = E * 128

16 Bit Hexideolmal	Decimal Computer	Engineering Unit	Coolant Temperature	
Address	Unit	(% Chng.)	deg. C	Acceleration Enrichment Multiplier Calculation
846E	255 (144)	1.99 (1.126)	-40	
846F	255 (144)	1.99 (1.125)	-28	Delivered PW = BINJ [Adaptive Mode * Decel Mode + Accel Mult.] + CL Corr + Inj Cor
8470	255 (128)	1.99 (1.0)	-16	- BPINJ
8471	255 (124)	1.99 (0.97)	-4	
8472	245 (118)	1.91(0.92)	8	BPINJ = BPINJ + (BPINJ)(AE FACTOR)
8473	164 (80)	1.28 (0.625)	20	
8474	130 (64)	1.02 (0.6)	32	AE FACTOR = [(Load AE Mult. + Delta Throttle Poe. AE Mult.) - Limit] - Decay Rate
8476	118 (58)	0.92 (0.44)	44	< Table F91 > < Table F102>
8476	92 (44)	0.72 (0.34)	66	
8477	66 (32)	0.52 (0.25)	68	
8478	50 (24)	0.39 (0.19)	80	Additional fuel delivered 'saynohronously' with base PW - based on rapid changes in
8479	17 (10)	0.13 (0.08)	92	measured throttle position (TPS)
847A	17 (10)	0.13 (0.08)	104	
847B	17 (10)	0.13 (0.08)	116	
647C	17 (10)	0.13 (0.06)	128	

Table F80 Cold Engine F/A % Ching vs. LV8 - Load and CLDEGFLT Conversion Equation N = % Change * 2.56

-26 deg. C		-4 deg. C			20 deg C			44 deg. C			68 deg C			
16 BK	Decimal	Engineering		Decimal	Engineering		Decimal	Engineering		Decimal	Engineering		Decimal	Engineering
Heeddecimal	Computer	Unit	Hexideoimai	Computer	Unit	Hexidecimal	Computer	Unit	Hexidecimal	Computer	Unit	Hexidecimal	Computer	Unit
Address	Unit	(% Chng.)	Address	Unit	(% Chng.)	Address	Unit	(% Chng.)	Address	Unit	(% Chng.)	Address	Unit	(% Ching)
86D9	33 (36)	13 (14)	86EA	31 (34)	12.3 (19.3)	85FB	33 (36)	13 (14)	860C	12 (13)	4.5 (5)	861D	0	0
86DA	33 (96)	13 (14)	86EB	31 (34)	12.3 (13.3)	86FC	39 (36)	13 (14)	860D	29 (32)	11.5 (12.5)	861E	0	0
8608	33 (36)	13 (14)	86EC	31 (34)	12.3 (15.3)	86FD	33 (36)	13 (14)	860E	31 (34)	12.5 (13.3)	861F	13	6
86DC	33 (36)	13 (14)	86ED	31 (34)	12.3 (13.3)	85FE	33 (36)	13 (14)	860F	31 (34)	12.3 (19.3)	8620	26	10
8 500	36 (36)	14 (15)	85EE	33 (36)	13 (14)	86FF	33 (36)	13 (14)	8610	31 (34)	12.3 (13.9)	8621	36	14
860E	37 (40)	14.6 (15.6)	85EF	36 (38)	14 (15)	8600	36 (38)	14 (15)	8611	33 (36)	13 (14)	8622	37	14.4
86DF	39 (42)	15.4 (16.4)	85F0	37 (40)	14.6 (15.6)	8601	36 (39)	14.2 (15.2)	8612	36 (38)	14 (15)	8623	38	15
85EO	46 (48)	17.8 (18.8)	85F1	44 (46)	17 (18)	8602	41 (44)	16 (17)	8613	37 (40)	14.6 (15.6)	8624	40	15.6
85 E1	47 (50)	18.5 (19.5)	85F2	46 (48)	17.8 (18.8)	8603	46 (48)	17.8 (18.8)	8614	39 (42)	15.4 (16.4)	8625	41	16
86 E2	51 (54)	20 (21)	86F3	49 (52)	19.9 (20.3)	8604	47 (50)	18.5 (19.5)	8615	41 (44)	16 (17)	8626	42	16 4
86 E3	55 (57)	21.3 (22.3)	86F4	54 (58)	21 (22)	8605	49 (52)	19 3 (20 3)	8616	47 (50)	18.6 (19.5)	8627	43	16 8
86 E4	56 (5 9)	22 (23)	86F5	56 (58)	21.7 (22.7)	8606	51 (54)	20 (21)	8617	49 (52)	19.3 (20.3)	8626	44	17
86 E5	59 (61)	23 (24)	86F6	57 (60)	22.4 (23.4)	8607	54 (56)	21 (22)	8618	51 (54)	20 (21)	8629	44	17
86 E6	59 (61)	23 (24)	85F7	57 (60)	22.4 (23.4)	8608	56 (56)	21.7 (22.7)	8619	51 (54)	20 (21)	862A	44	17
86 E7	59 (61)	23 (24)	85F8	57 (60)	22.4 (23.4)	8609	56 (58)	21.7 (22.7)	861A	51 (54)	20 (21)	8628	44	17
86 E8	59 (61)	23 (24)	85F9	57 (6 0)	22.4 (23.4)	860A	56 (58)	21.7 (22.7)	861B	51 (54)	20 (21)	862C	44	17
96 E9	59 (61)	23 (24)	86FA	57 (60)	22.4 (23.4)	860B	56 (58)	21.7 (22.7)	861C	51 (64)	20 (21)	862D	44	17
	dea C			deg. C										Ì
16 BR	Decimal	Engineering	16 Bit	Decimal	Engineering		LV8 -Load							ŀ
	Computer		Hexideolmel	Computer	Unit	1	(for each							Į.
Address	Unit	(% Chng.)	Address	Unit	(% Chng.)	-	series)	_	pen Loop F/A	. Calaudada				- 1
962E	0	0	863F	0	0		0	•	pen Loop Fis	Carchiago	71			
962F	0	0	8640	0	0	1	16	_		- O1 E/A	I M Endah \ .	(%Enrich: Tin	Out \ . (A	
0630	13	5	8641	13	5	i	32 48	Ç	pen Loop F/A		(76Emion.) + (Table F5 0 >	Table F		OU. MOOS)]]
8681	26	10	8642	26	10	1	í			•	C TRUM FOU >	< 1800mm FC) (>	1
8632	36	14	8643	36	14	j	64							1
8633	37	14.4	8644	37	14.4	1	80							1
8634	38	15	8645	38	15	j	98							Į.
8686	30	15.2	8646	38	15		112	•/	Endoh Time (~ ^ ^ h		load ava dasa	ur fi motion	ŀ
9636	40	15.6	8647	38	15	ſ	128	76	ennon, Inno-C	ט כ-⊷ זעכ	y a precessim	ined exp. deca	ly lunction	i
8637	40	15.6	8648	38	15	1	144	•	Enrichment	- 1 at nois	ut uthere elega	d loop switche		- 1
8638	40	15.6	8649	38	15	ì	160	74	Enrichment -	·> rection	IL MINNE CIUSE	u loop switche	•	1
8639	40	15.6	864A	38	15	ŀ	176							J
863A	40	15.6	864B	38	16	J	192							- 1
8636	40	15.6	864C	38	15	1	206							1
863C	40	15.6	864D	38	15	1	224							1
903D	40	15.6	864E	38	15	1	240							}
863E	40	15.6	864F	38	16		256				فالمستوية بالمستويرات	سبسب الدرسيس البراد		

Table F61 Time Out F/A % Ching Init Value vs. Coolant Temp Conversion Equation N = % Change * 1.28

16 Bit	Decimal	Engineering	Coolant	
Hexidecimal	Computer	Unit	Temperature	
Address	Unit	(% Chng.)	deg. C	Open Loop F/A Calculation
8650	150 (160)	117.2 (125)	-40	
8661	150 (160)	117.2 (125)	-28	Open Loop F/A = C.L. F/A [(%Enrich.) + (%Enrich. Time-Out) + (Add. Mode)]
8652	128 (139)	100 (108.6)	-16	< Table F50 > < Table F51>
8663	100 (112)	78 (87.5)	-4	
8654	49 (56)	36 (44)	8	Closed Loop F/A Calculation
8655	35 (42)	27 (33)	20	
8656	23 (28)	18 (22)	32	Closed Loop F/A = C.L. Stoloh F/A [1 + (%Enrich. Time-Out)]
8657	16 (22)	14 (17)	44	< Table F51 >
8658	13 (16)	10 (12.5)	58	
8659	13 (16)	10 (12.5)	68	
865A	13 (16)	10 (12.5)	80	
8668	11 (14)	8.6 (11)	92	%Enrich. Time-Out> 0 by a predetermined exp. decay function
866C	11 (14)	8.6 (11)	104	
865D	11 (14)	8.6 (11)	116	

Table F64 Crank Fuel PW vs. Coolant Temperature

Conversion Equation N = E * 256 / KSCAL64

16 Bit	Decimal	Engineering	Coolant	
Hexidecimal	Computer	Unit	Temperature	
Address	Unit	(maec.)	deg. C	
86 E6	163 (179)	119 (131)	-40	Cranking Fuel Pulse Width Calculation
86 E7	156 (172)	114 (126)	-26	
86 E8	135 (148)	99 (108.4)	-16	Crank PW / Rev = (Crank PW) (Crank PW Time - Out) (Constant)
86 E9	96 (105)	70 (77)	-4	< Table F64 > < Table F65>
86 EA	78 (86)	57 (63)	8	
ee EB	45 (48)	33 (35)	20	
86 EC	37 (40)	27 (29)	32	Crank PW - Duration per crank revolution (1/2 total fuel / cylinder)
86 ED	30 (33)	22 (24)	44	
86 EE	19 (21)	14 (15.4)	56	At <450 rpm and <95 deg. F - 1/3 Crank PW injected 3 times per revolution
86 EF	16 (18)	12 (13)	68	· · · · · · · · · · · · · · · · · · ·
86F0	14 (16)	10 (12)	80	
86F1	14 (16)	10 (12)	92	
66F2	14 (16)	10 (12)	104	
86F3	17 (19)	12.5 (14)	116	

Table P65 Crank Fuel PW Multiplier vs. Reference Pulsee

Conversion Equation N = E * 256

16 Bit	Decimal	Engineering	Crank	
Hexideoimel	Computer	Unit	Reference	
Address	Unit	(meeo.)	Pulses	
86F4	170 (192)	0.66 (0.75)	0	
86F5	106 (128)	0.41 (0.5)	8	Cranking Fuel Pulse Width Calculation
86F6	105 (128)	0.41 (0.5)	16	
86F7	106 (128)	0.41 (0.6)	24	Crank PW / Rev = (Crank PW) (Crank PW Time - Out) (Constant)
86F8	105 (128)	0.41 (0.5)	32	< Table F64 > < Table F65>
86F9	105 (128)	0.41 (0.5)	40	
86FA	105 (126)	0.41 (0.5)	48	
66FB	105 (126)	0.41 (0.5)	56	Crank PW Time-Out - Crank PW Multiplier
86FC	105 (128)	0.41 (0.5)	64	
86FD	105 (128)	0.41 (0.5)	72	At <450 rpm and <95 deg. F - 1/3 Crank PW injected 3 times per revolution
86FE	105 (128)	0.41 (0.5)	80	
86FF	105 (128)	0.41 (0.5)	88	3 Reference pulses per revolution
8700	105 (128)	0.41 (0.5)	96	
8701	105 (128)	0.41 (0.5)	104	
8702	105 (128)	0.41 (0.6)	112	
8703	106 (128)	0.41 (0.5)	120	
6704	105 (128)	0.41 (0.5)	126	

Table F17 Idle Air Control (IAC) Command Speed vs. Coolant Temp Conversion Equation N = E / 12.5

16 BR	Decimal	Engineering	Coolant	
Henddeolmel	Computer	Unit	Temperature	
Address	Unit	(rpm)	deg. C	IAC Command Speed Calculation
8967	136	1700	-40	
8958	128	1600	-28	Command Idle RPM - Base Idle RPM + RPM Offset
8959	112	1400	-16	< Table F17 >
895A	104	1900	-4	
896B	104	1300	8	Four Modes of Operation
696C	96	1200	20	
896D	96	1200	32	Start-up Delay - IAC motor initially moved to warm park' position
896E	80	1000	44	
895F	72	900	56	Open Loop - IAC motor retracts until actual rpm equals desired rpm
8960	72 (70)	900 (875)	68	
8981	72 (68)	900 (850)	80	Closed Loop - IAC motor regulates to achieve desired rpm
8962	72 (68)	900 (850)	92	
8963	72 (68)	900 (850)	104	Throttle/Load Compensation - IAC motor compensates idle speed for
8964	72 (69)	900 (863)	116	applied loads (A/C, Pwr Steering, etc.)
8965	72 (70)	900 (875)	128	
8966	72	900	140	
8967	72	900	152	

Table F76 EGR Duty Cycle vs. LV6 - Load and RPM Conversion Equation N = E * 256

			1	1000 RPM		I	1200 RPM			1400 RPM			1600 RPM	
16 BK	Decimal	Engineering	16 Bit	Decimal	Engineering	16 Bit	Decimal	Engineering	16 BH	Decimal	Engineering	16 BH	Decimal	Engineerin
Heeddeolmel	Computer	Unit	Hexidecimal	Computer	Unit	Hexideolmal	Computer	Unit	Hexideoimal	Computer	Unit	Hexidecimal	Computer	Unit
Address	Unit	(DC%)	Address	Unit	(DC %)	Address	Unit	(DC %)	Address	Unit	(DC %)	Address	Unit	(DC %)
6308	0	0	8314	0	0	831D	0	0	8326	0	0	832F	0	0
880C	0	0	8315	0	0	831E	0	0	8327	0	0	8330	0	0
830D	0	0	8316	0	0	831F	0	0	8328	0	0	63 31	30 (26)	11.7 (10)
830E	0	0	8317	15 (13)	5.9 (5)	8320	43 (36)	16.6 (15)	8329	74 (64)	28.9 (25)	8332	103 (90)	40 2 (35)
830F	0	0	8318	30 (26)	11.7 (10)	8321	58 (51)	22.7 (20)	832A	103 (90)	40.2 (35)	8333	132 (115)	51.6 (45)
8910	0	0	8319	43 (38)	16.8 (15)	8322	74 (64)	28.9 (25)	8328	117 (102)	45.7 (40)	8334	147 (128)	57.4 (50)
8311	0	0	831A	58 (51)	22.7 (20)	8323	88 (77)	34.4 (\$0)	832C	132 (115)	51.6 (45)	8335	162 (141)	63.3 (55)
8312	0	0	831B	74 (64)	28.9 (25)	8324	103 (90)	40.2 (35)	832D	147 (126)	57.4 (50)	8336	168 (146)	65 6 (57)
8313	0	0	831C	88 (77)	34.4 (30)	8326	103 (90)	40.2 (35)	832E	162 (141)	63.8 (55)	83 37	177 (154)	69.1 (60)
	1800 RPM			2000 RPM			2200 RPM			2400 RPM			2600 RPM	
16 BR	Decimal	Engineering	16 B#	Decimal	Engineering	16 Bit	Decimal	Engineering	16 Bit	Decimal	Engineering	16 Bit	Decimal	Engineering
Hesddeoimel	Computer	Unit	Hexideolmai	Computer	Unit	Hexidecimal	Computer	Unit	Hexidecimal	Computer	Unit	Hexideolmal	Computer	Unit
Address	Unit	(DC%)	Address	Unit	(DC %)	Address	Unit	(00%)	Address	Unit	(DC %)	Address	Unit	(DC %)
9338	0	0	8341	0	0	834A	0	0	8353	0	0	835C	0	0
9339	0	0	8342	0	0	834B	0	0	8354	0	0	63 6D	0	0
833A	43 (38)	16.8 (15)	8343	58 (51)	22.7 (20)	834C	43 (38)	16.8 (15)	8366	30 (26)	11.7 (10)	835E	0	0
8558	103 (90)	40.2 (35)	8944	103 (90)	40.2 (35)	834D	103 (90)	40.2 (35)	8356	88 (77)	34.4 (30)	63 5F	74 (64)	28.9 (25)
839C	132 (115)	51.6 (45)	8345	132 (115)	61.6 (45)	834E	147 (126)	51.6 (45)	6357	132 (115)	61.6 (45)	8360	117 (102)	45.7 (40)
8330	147 (126)	57.4 (50)	8346	147 (12 8)	57.4 (50)	834F	162 (141)	57.4 (50)	8358	147 (128)	51.6 (45)	8361	147 (128)	57.4 (50)
esse	177 (164)	69.1 (60)	8347	177 (154)	69.1 (60)	8 350	177 (1 54)	69.1 (60)	8359	177 (154)	89.1 (80)	8362	177 (154)	69.1 (60)
633F	185 (181)	72.3 (63)	8348	190 (166)	74.2 (66)	8951	190 (166)	74.2 (66)	836A	190 (166)	74.2 (65)	8363	190 (166)	74.2 (66)
\$34 0	190 (166)	74.2 (66)	8349	205 (179)	80.1 (70)	8362	205 (179)	80.1 (70)	836B	190 (166)	74.2 (65)	8364	190 (166)	74.2 (65)
	2800 RPM			3000 RPM		<u> </u>		_						
16 Bk		Engineering	16 BH	Decimal	Engineering	{	LV8 Load	•	EGIR Duty Cy	xie Calculati	on			
	Computer		Hexidecimal	Computer	Unit	1	(for each	_			A / FAR B .			
Address	Unit	(DC %)	Address	Unit	(DC %)	ļ.	series)	Ł	•			Coolant Mult	,	
8365	0	0	836E	0	0		32		<	Table F76 >	< 1840	le F77 >		
8366	0	0	636F	0	0	1	48		EVRV DC	E0.	R Valve Press	. 60	R Valve Pos	
8367	0	0	8370	0	0	J	64			EG			ed (normally	. 1
8366	74 (64)	28.9 (25)	8371	74 (64)	28.9 (25)	l	80	^	0% cDC < 100%		alm. 10 - 24 kPa		racioble lift	' i
	117 (102)	45.7 (40)		117 (102)	45.7 (40)	1	96	0 -				•	fully open	ł
	147 (128)	57.4 (50)		147 (128)	57.4 (50)	-	112		100%	rr	ian. Vacuum		iony openi	j
	177 (154)	69.1 (60)		177 (154)	69.1 (60)	į	128	e	VRV - Electro	anh Veri	Damiletor \/=	h/a		1
	190 (166)	74.2 (65)		190 (166)	74.2 (65)		144	E	ALIA . EMBCE	NEW VENUEN	Lafiniern Au			í
\$36 D	190 (166)	74.2 (65)	8376	190 (166)	74.2 (66)		160							

Table F77 EGR Duty Cycle Multiplier vs. Coolant Temp Conversion Equation N = E * 128

16 Bit Hexideolmal	Decimal Computer	Engineering Unit	Coolant Temperature	EGR Duty Cycle Calculation
Address	Unit	(gein)	deg. C	
8377	0	0	-40	EGR DC = (EGR Base DC) (EGR DC Coolant Mult)
8378	35 (32)	0.27 (0.25)	-28	<table f76=""> <table f77=""></table></table>
8379	85 (60)	0.66 (0.625)	-16	
837A	125 (120)	0.98 (0.94)	-4	EGR DC = 0 when:
837B	158 (152)	1.23 (1.19)	8	* park / nuetral
837C	170 (168)	1.39 (1.31)	20	* manifold air temp. (MAT.) < -40 deg. C
	, ,	, ,		 throttle position (TPS) < 2.7%, if not currently equal to zero
				* throttle position (TPS) < 4.3%, if ourrently equal to zero
			[power enrichment mode enabled - TPS > 60% engine warmed

APPENDIX B Oil Sample Test Reports

EXAS TECH UNIVERSITY ATTN: DR. TIM MAXWELL

79409

P.O. BOX 41021

LUBBUCK TX

COMOCO MONITORED MAINTENANCE ade Chi Anabas Program TEST REPORT

'88 CORSICA Unit No:

Company.

TEXAS TECH UNIVERSITY

LUBBOCK TX Location

ENGINE Component: Make & Model CHEVY N/G

Atlanta, GA

(404) 454-8000

Oil Capacity N/G

041591 '88 CORSICA OH Type: Computer-Code-+> SAMPLE INFORMATION SPECIFICATIONS FOR THIS OIL ARE NOT AVAILABLE. TRACE WATER DETECTED. NO GLYCOL DETECTED. SUSPECT AB NO. 1-06/30/94 CONDENSATE, SUSPECT SILICON IS FROM ENGINE SEALANT (GASKET MATERIAL). SUSPECT ABNORMAL CYLINDER imple Drawn 07/11/94 AREA WEAR. CHECK FOR POWER LOSS, BLOW-BY, SMOKING, OIL CONSUMPTION, ETC. CHANGE OIL AND FILTER IF eport Date 19457 NOT DONE AT TIME OF SAMPLING. RESAMPLE AT NORMAL INTERVAL. [# VISCOSITY APPEARS LOWER THAN USUAL II/HR Unit: 3000 FOR MOTOR MILHR OIL NORMAL OIL.] ii Added: 509269705 note viscosity. (Low): inspect fuel system for defects. Telecon. (Evaluator-mike costello) per dr. AB NO. 2-09/20/94 TIM MAXWELL: UNIT HAS HAD PROBLEMS WITH FUEL PUMP. FUEL IS 100% Sample Drawn: 09/29/94 METHANOL. leport Date: 27000 II/HR Unit: 7000 MI/HR Oil: NORMAL il Added: AB NO. 3ample Drawn: eport Date: II/HR Unit: II/HR Oil: Oil Added: AB NO. 4ampie Drawn: Report Date: II/HR Unit: M/HR Oil: Sil Added: AB NO. 5ampie Drawn: eport Date: MI/HR Unit: II/HR Oil: ii Added: LAB NO. 6ample Drawn: eport Date: MI/HR Unit: MI/HR Oil: il Added:

		- 10000				<u></u>																				
	로_			PHYSIC	AL DA	TA			L	ELEMENTAL CONCENTRATIONS IN PARTS PER MILLION (PPM) BY WEIGHT																
	1 0	00c St	WATER	DET /	SOLIDS	4000rmc4	(-04F-0Z	TRAT-OX		W-1-002			ZCZWOWYLOZ	Z-OXWJ	202-202	r-4	COPPME	JEAO	w-1>ma	800-D#	BOROZ	ZAGZWG-DZ	A	١ 🚡	CDOTA	Z I ZC
ter		8.1	0.2	VOI		1 % Wt	Aven	Wcm)		44	293	21	M	\	- Me	177	60	35		<u>k1</u>	}	1118	700	0	8 98	2181
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The validity of comments/recommendations is dependent on accurate, comments sample information, and representative oil sample.

MONITORED MAINTENANCE Lube Oil Anansis Program TEST REPORT

TEXAS TECH UNIVERSITY ATTN: DR. TIM MAXWELL P. O. BOX 41021

LUBBUCK , TX, 79409

Unit No

LIC#577-492

Company MECH ENGINEERING

Component ENGINE

Make & Model

CHEVY N/G

Atlanta, GA (404) 279-1370 Oil Capacity 4 QTS. Oil Type: LUBRIZOIL

	SAMPLE IN	FORMATION					COMMENTS				
_ ,,	4B NO. 1-	00 92259 20	DIRT (SIL	.icon) proeael	y assenbly	CONTAMINATI	DX. # SUSPECT	F BREAK-IN NATER	IAL. CHANGE DI	IL AND FILTER	
	imple Drawn	K/C	– IF NOT D	CIME AT TIME (F SAMPLING	. (EVALUATUR	-RALPH PINE).				
	eport Date:	09/24/93									
	FHR Unit:	13,458									
	I/HR Oil:	N/G									
	il Added:	į									
	4B NO. 2-										
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	WHA Oil:										
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TEXAS TECH UNIVERSITY ATTN: DR. TIM MAXWELL P.O. BOX 41021 LUBBUCK , TX, 79409 CONOCO MONTTORED MAINTENANCE Lute Oil Anahas Program TEST REPORT

Unit No: '88 CORSICA

Company: TEXAS TECH UNIVERSITY

Location: LUBBOCK TX
Component: ENGINE
Make & Model: CHEUY

Make & Model: CHEVY N/G
Oil Capacity:

Atlanta, GA

Oil Type: LUBRIZOL 05#796164

SAMPLE IN	FORMATION	$\overline{}$				<u>-</u>		404	•) 4	74-	800		MENT	I Type	<u> </u>	JBK	LZUL	_ U	5#7°	7616	54		
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MONITORED MAINTENANCE EXAS TECH UNIVERSITY Like Chi Anahas Program ATTN: DR. TIM MAXWELL TEST REPORT P.O. BOX 41021 Atlanta, GA UBBUCK TX 79409 (404) 454-8000 Computer-Code--> SAMPLE INFORMATION72 48 NO 1-11/18/94 imple Drawn 12/02/94 port Date: 31000 HR Unit: 3500 M HR Oit NORMAL Added: 48 NO. 2-Sample Drawn: eport Date: ⊬HR Unit: MUHB Oit: :I Added: 4B NO. 3ample Drawn: eport Date: L'HR Unit

123583 Unit No: TEXAS TECH UNIVERSIT Company

Location

ENGINE Component: N/G N/G

Make & Model:

N/G Oil Capacity.

041591 123583 Oil Type: INSUFFICIENT INFO GIVEN TO PROVIDE ACCURATE EVALUATIONED DATA, SUSPECT ABNORMAL CYLINDER AREA WEAR. SUSPECT RING WEAR. VALVE AREA WEAR INDICATED (NICKEL). CHECK FOR POWER LOSS, BLOW-BY, SMOKING, OIL CONSUMPTION, ETC. SUSPECT ABNORMAL MAIN/CONN. ROD BEARING WEAR. WEAR NOT MAJOR. BUT SHOULD BE NOTED. CHECK FOR KNOCKING AND/OR LOSS OF OIL PRESSURE. RECOMMEND CLOSE MONITORING. RESAMPLE AT ONE HALF NORMAL INTERVAL. (EVALUATOR - G.D.) WHR Oil: Oil Added: AB NO. 4ample Drawn: Report Date: dt/HR Unit I/HR Oil: Sil Added: AB NO. 5ample Drawn: eport Date: MI/HR Unit: MAR OIL ii Added: LAB NO. 6ample Drawn: eport Date: MI/HR Unit: MI/HR Oil: il Added: PHYSICAL DATA ELEMENTAL CONCENTRATIONS IN PARTS PER MILLION (PPM) BY WEIGHT N-ZO SOO S LOKE. S N. 101 å PERE 100C ġ 222 ã ∕cSt TAN A/cm/A/cm % Wt 1832 2553 С В В 8 8 5

Abnormal values are coded to indicate degree of seventy.

C = High value. Normally requires D = Severe abnormality indicated B = Slightly above normal.

The validity of comments/recommendations is dependent on accurate complete sample information and representative oil sample.

TEXAS TECH UNIVERSITY ATTN: DR TIM MAXWELL P. O. BOX 41021 LUBBUCK / TX/ 79409



Unit No.

Oil Capacity.

Company

TEXAS TECH UNIVERSITY Location:

Component UBBOCK TX Make & Model ENGINE

CHEVY N/G

Atlanta, GA

5 GTS Oil Type:

(404) 454-8000 LUBRIZOL SAMPLE INFORMATION COMMENTS AB NO 1-DIL NEG. , TRADEMANE, AND/OR SAE/ISD GRADE OF DIL NOT GIVEN. HIGH LEVEL OF DIRF DETECTED. GENERALIZED 01/0019921 ample Drawn 09/24/93 (MON-SPECIFIC) WEAR INDICATED, CHANGE OIL AND FILTER IF NOT DONE AT TIME OF SAMPLING. eport Date (EVALUATOR-RALPH PINE). 10/06/93 JUHA Unit: 17,177 MHA ON 3,727 il Added: AB NO. 2-Sample Drawn: eport Date: II/HR Unit: MI/HR OIL d Added 48 NO. 3ample Drawn: eport Date: II/HR Unit: MI/HR Oil: Qil Added: AB NO. 4ample Drawn: Report Date: 11/HA Unit: IVHA Oil: Oil Added: AB NO. 5ample Drawn: Report Date: MI/HR Unit: 11/HR Oil: Jil Added: LAB NO. 6ample Drawn: leport Date: MI/HR Unit: 4I/HR Oil:)il Added: PHYSICAL DATA ELEMENTAL CONCENTRATIONS IN PARTS PER MILLION (PPM) BY WEIGHT 001 アンドロ 701 100 d CST A/cm\A/crr 8.5 (.03 <.1 8 12 207 3 9 30 47 27 0 47 0 2060 57 0 1072 2157 31

APPENDIX C

Emissions Test Resultsfrom Southwest Research Institute

FAX COVER LETTER

DATE: 02/22/93			
PLEASE DELIVER TO:	Mr. Jessa Jones		
FAX NUMBER:	806-742-3540		
FROM: Kevin Whitne	ev. Phone: 210-522-5869	Swri Charge No08#	_
Southwest Research Institute Department of Emissions In Automotive Products and In Fax Number (512) 522-395	Research Emissions Research Divisio	n	
WE ARE TRANSMITTING	PAGES (ii	ncluding this cover page)	
If transmission is not complete	please call (512) 522-2609		
MESSAGE:			 -

Here a new copies of the data, the are no changes but they're a bit easier to read. The reason the values for NMOG and THC are similar is because of how each is calculated. The calculations are as follows:

NMOG = NMHC + CARBONYL + ALCOHOL

THC = NMOG + 0.0043*CH4

Dear Jesse:

As you can see, for CARB calculation purposes THC is a calculated number rather than from a FID analyser. This is how the confusion arose. Please note that this data does not have a RAF applied to it. It is 0.41 for M85, but I'm not sure what it is for M100. If you have any other questions, feel free to call me at 210-522-5869.

Sincerely,

Kevin A. Whitney ---

Engineer

Department of Emissions Research

COMPUTER PROGRAM LDT 1.0-R 3-BAG CARB FTP VEHICLE EMISSION RESULTS PROJECT NO. 08-4527-008

ENGINE	88 CHEVY 2.8 L (17	CORSICA 1 CID)-7-6	DATE 1 DYNO 2	-TT-01 /19/93 RUN BAG CART 2 ROAD LOAD 7.70 HP IGRT 3500 LBS (19	P H	ETHANOL EN-1399- UEL DENSITY 6.67 1.126 C .375 O	20 LB/GAL
RELATIVE HUNTDI	TTV 38.6 PC	T .		erature 72.0°F (22.2°C) N	OX HUMIDITY C.P.	.880
RAG KUNERER	5070		1	2		3	
BAG MUMBER BAG DESCRIPT	ION		COLD TRANSIE	MT STABILI (505-1372	ZED BOT	TRANSIENT	
ROW TIME SECO	ONDS		505.2	867.0	5	605.4	
DAY AURT (CODD)	PARTAN PLAN	NOD SAME/RAC	¥ 977 / 92G	980/.9	RQ .97	12/_989	
MEASURED DIS	TANCE MILES	S (KOE)	3.58 (5.76	3.83 (6	.16) 3.57	7 (5.74)	
BLOWER FLOW	RATE SCPN ((SCMM)	557.2 (15.7	8) 556.9 (1	5.77) 556.	5 (15.76)	
GAS HETER FL	OW RATE SCI	TH (SCHIN)	.27 (.01	.27 (.01) .27	7 (.01)	
				3.83 (6 8) 556.9 (1) .27 (9) 8051. (2			
RC SAMPLE N	ETER/RANGE	/PPH (BAG)	37.8/ 2/ 37	7.78 11.9/ 2/ 7.60 9.9/ 2/ 7.60 17.1/ 12/ 7.60 17.1/ 12/ 7.60 17.1/ 12/ 7.60 17.1/ 12/ 7.60 17.1/ 14/ 7.60 1.89 11.5	2/ 11.49		
HC BCKGRD N	ETER/RANGE,	/PPH	7.6/ 2/ 7	.60 9.9/ 2/	9.89 9.7	/ Z/ 9.69	
CO SAMPLE N	ETER/RANGE	/PPN	33.6/ 12/ 32	2.60 17.1/ 12/	16.47 10.6,	/ 12/ 10.16	
CO BCKGRD N	ETER/RANGE,	/PPM	1.1/ 12/ 3	.04 1.4/ 12/	1.33 1.3,	121 1.23	
COZ SARPLE H	EKTEK/RANGE.	/PCT	77.8/ 14/ .6	0203 6/-4/ 14/	.4640 /4.1,	/ 14/ .5601	
COS DONGED II	ETEK/BARGO, Durum (daram)	/FC] /1994 /536\ /f	14.U/ 14/)U 3)	15.13 14/ 140 27/ 1	.U400 13.0;	/ 14/ .04/0 / 1/ £ 77	
NOT DONOUGH	ieter/Range Hondo (dince	/PPE (DAG) (1)) 45.6/ 1/ 1/ 1.5/ 1/	1.43 Z.// 1;	.00 Zi.U	/ 1/ 0.77 ! 1/ 00	
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CH4 BOKGRD P	PM		2.54	2.7/ 1; .38 1.9/ 1; 3. 2. 24. 24. 41 41	52	2.51	
DILUTION FAC	CTOR		18.42	24.	.78	20.57	
HC CONCERT	TRATION PPN		30.59	2.	40	2.27	
CO CONCENT	eration ppn	Í	30.61	14.	. 7 7	8.70	
CO2 CONCENT	TRATION PCT		.5751	.41	· 93	.5154	
NOX CONCENT	PRATION PPN	Į.	11.07		. 22	6.51	
CH4 CONCENT	TRATION PPH		1.88	1.	.13	2.00	
MARC CONCENS	FRATION PPM	ł.	.13	1	.07	.02	
	GRAMS		6.521		365	.189	
	GRANS		4.737		920	1.345	
	GRAMS		1399.64			1253.19	
	GRAMS GRAMS		2.478 .167		385 172	1.454 .178	
	GRANS (FII	3)	.010		141	.001	
FUEL KASS		,	1.031		279	03.4	
FUEL ECONON		OOKIK)	10.43 (22			.71 (20.08)	A &
	•	,					MIN FR
3-BAG COMPOSI							818 878 BJ
	THC	G/NI	.40	CH4	G/MI .04	17	V -
	00	G/MI	.91	NNBC	G/MI .02	20	ANNATE
	MOX	G/NI	.27		YL G/MI .04	9	GUENERO
	pre-en-	DANIAN	/# /4.6.0PM/		OL G/NI .30	b ?	
	PUEL	ECOMONY MPG	(L/100KM) 9.91	(23.73) NHOG	G/HE .3	96	CARRENT MIR FA AT BIB STS GT TO BIB STS GT TO STORE GUERRO 3. 12 CR O3/
							۴ *

COMPUTER PROGRAM LEFT 1.0-R 3-BAG CARB FTP VEHICLE EMISSION RESULTS PROJECT NO. 08-4527-008

	DEL	88 CHEVY CO	rsica CID)-V-6		RUM		HETHANOL ER-1399-I FUEL DENSITY 6.620 H .126 C .375 O .	LB/GAL
TRANSMISSI	∆¥	SH (T)	015, . 0	ACTUAL ROAD LOA			<u> </u>	
ODONETER				TEST WEIGHT 35				
		0 IN BG (744 TY 38.6 PCT.		DRY BULB TEMPERATURE	72.0°F (22.2	2°C)	NOX BUNIDITY C.F.	.880
BAG MUNB	ER		1	2	3			
BAG DRSC	RIPTI	OM CO1/D	TRANSTERM		BOT TRANSI	KNY	BACKGROUND	
		(0)-505 SEC. }	(505-1372 SEC.)	(0- 505 :	SEC.)		
FORKALDE	MYDE	, -	,	(,	(0 000 0	,		
PPK			.252	.008	.011		.014	•
NASS			38.71	.00	.00		1441	
ACETALDE			30.71	.00	.00			
PPH			.035	.015	.005		.002	
KASS			7.83	5.54	.65		1002	
ACROLEIN			7.43	5.54	.00			
	1		A15	000	000		600	
PPN			.015	.000	.000		.000	
MASS	MG		4.39	.00	.00			
ACETONE								
PPM			.048	.059	.036		.013	
MASS			11.22	25.06	7. 57			
PROPIONA	/TDBH/	DE						
PPN			.010	.000	.000		.000	
Mass	MG		3.13	.00	. 0 0			
CROTONAL	DEHAI)E						
PPM			.000	.000	.000		.000	
Mass	NG		-00	.00	.00			
ISOBUTY	R+MEK							
PPM			.000	.001	.000		.001	
HASS	MG		.00	.04	.00			
RENZALD								
PPM			.000	.000	.000		.000	
MASS	NG		.00	.00	.00			
HEXANALI		R		•••				
PPK	~ ~ ~ ~ .	-	.000	.000	.000		.000	
MASS	NG		.00	.00	.00		1000	
METHANO			100	•00	.00			
PPE	_		36.444	.238	.173		.171	
MASS	¥C.	E	279.27	21.59	1.45		•111	
ethanol		9	213.21	21.33	1.43			
PPH			.000	.000	.000		.000	
WASS	W/I		.00	.00	.000		.000	
HADD	πu		_QU	. IAI	.00			
3-BAG COM	POSIT	e resolts						
		PORMALDEHYDE	HG/HI	2.247	CROTONALD.	NG/HI	.000	
		ACETALDERYDE	•	1.253	ISOBUTYR+MEK		.005	
		ACROLEIN	MG/MI	.255	BENZALDERYDE	•	.000	
		ACETONE	MG/MI	4.622	HEXANALDERADE	•	.000	
		PROPIONALD.	•	.182	NETHANOL	MG/MI	367.478	
		· AUL TURALEU		.102	ETHANOL	NG/NI	.000	
					UI HUDVL	witni	.000	

COMPUTER PROGRAM LIFT 1.0-R 3-BAG CARB FTP VEHICLE ENISSION RESULTS PROJECT NO. 08-4527-008

VERICLE NUMBER 577 VEHICLE MODEL 88 CHEVY CORSICA ENGINE 2.8 L (171 CID)-V-6 TRANSMISSION 5N ODONETER 9258 MILES (14896 K	TEST CC-TT-02 DATE 1/20/93	RUN	HETBAROL EN-1399-F FUEL DENSITY 6.620 LB/GAL
ENGINE 2.8 L (171 CID)-V-6	DYNO 2 BA	G CART 2	H .126 C .375 O .499 X .000
TRANSMISSION 5N	ACTUAL ROAD LOA	D 7.70 HP (5.74 KW))
ODOMETER 9258 HILES (14896 K	n) test weight 35	00 LBS (1587 KG)	
BAROMETER 29.32 IN HG (744.7 NN HG) RELATIVE HUNIDITY 44.2 PCT. BAG NUMBER BAG DESCRIPTION RUN TIME SECONDS DRY/WET CORRECTION FACTOR, SAMP/BACK MEASURED DISTANCE MILES (KM) BLOWER FLOW RATE SCPM (SCMM) GAS METER FLOW RATE SCPM (SCMM) TOTAL FLOW SCF (SCM)	DRY BULB TEMPERATURE	70.0 F (21.1 C)	NOX MUNIDITY C.F892
BAG KUNBER	1	2	3
BAG DESCRIPTION	COLD TRANSIENT	STABILIZED	HOT TRANSIENT
	(0-505 SEC.)	(505-1372 SEC.)	(0- 505 SEC.)
RON TIME SECONDS	505.3	867.7	507.1
DRY/WET CORRECTION FACTOR, SAMP/BACK	.976/.989	.9 79/.989	.977/.989
NRASURED DISTANCE NILES (KM)	3.57 (5.74)	3.82 (6.15)	3.57 (5.74)
BLOWER FLOW RATE SCPN (SCHN)	557.5 (15.79)	55 ?.1 (15.78)	556.6 (15.76)
GAS HETER FLOW RATE SCYN (SCHII)	.27 (.01)	.27 (.01)	.27 (.01)
TOTAL FLOW SCF (SCM)	4697. (133.0)	8061. (228.3)	4706. (133.3)
BC SAMPLE HETER/RANGE/PPN (BAG)	46.0/ 2/ 45.97	12.1/ 2/ 12.09	12.1/ 2/ 12.09
HC BCKGRD NETER/RANGE/PPN	9.4/ 2/ 9.39	11.0/ 2/ 10.99	10.7/ 2/ 10.69
CO SAMPLE METER/RANGE/PPM	58.1/ 12/ 56.81	13.6/ 12/ 13.06	11.8/ 12/ 11.32
CO BCKGRD HETER/RANGE/PPN	2.9/ 12/ 2.76	2.3/ 12/ 2.19	2.7/ 12 / 2.5 7
CO2 SAMPLE METER/RANGE/PCT	77.5/ 14/ .6152	67.7/ 14/ .4680	74.7/ 14/ .5695
CO2 BCKGRD NETER/RANGE/PCT	14.4/ 14/ .0494	14.5/ 14/ .0498	14.9/ 14/ .0515
NOX SAMPLE HETER/RANGE/PPN (BAG) (D	39.9/ 1/ 9.97	1.5/ 1/ .38	7.8/ 1/ 1.96
NOX BCKGRD METER/RANGE/PPN	2.3/ 1/ .58	3.4/ 1/ .78	1.0/ 1/ .25
CH4 SAMPLE PPH (1.120)	4.10	3.90	4.77
BC SAMPLE METER/RANGE/PPM (BAG) BC BCKGRD METER/RANGE/PPM CO SAMPLE METER/RANGE/PPM CO BCKGRD METER/RANGE/PPM CO2 SAMPLE METER/RANGE/PCT CO2 BCKGRD METER/RANGE/PCT MOX SAMPLE METER/RANGE/PPM (BAG) (D MOX BCKGRD METER/RANGE/PPM CH4 SAMPLE PPM (1.120) CH4 BCKGRD PPM	3.30	3.18	3.12
DILUTION FACTOR HC CONCENTRATION PPN CO CONCENTRATION PPN CO2 CONCENTRATION PCT NOX CONCENTRATION PPN CH4 CONCENTRATION PPN NNHC CONCENTRATION PPN	18.47	24.58	20.23
HC CONCENTRATION PPN	37.09	1.55	1.93
CO CONCENTRATION PPH	52.38	10.63	8.56
002 CONCENTRATION PCT	.5 685	.4202	.5206
NOX CONCENTRATION PPH	9.42	37	1.72
CH4 CONCENTRATION PPH	.98	. 85	1.80
NNHC CONCENTRATION PPH	.00	.59	04
TEC HASS GRAMS	8.136	.210	.163
CO KASS GRANS	8.112	2.824	1.328
CO2 HASS GRANS	1384.57	1756.07	1270.27
NOX MASS GRAMS	2.139	.000	.391
CH4 MASS GRAMS	.087	.130	.160
NNEC MASS GRAMS (FID)	.000	.078	.000
FUEL HASS KC	1.025	1.282	.926
FUEL BOONORY MPG (L/100KM)	10.45 (22.51)	3.96 (26.26)	11.56 (20.35)
3-BAG COMPOSITE RESULTS			
, TBC G/NI	.48	CB4 G/MI	.035
CO G/HI	.96	NNEC G/NI	.011
NOX G/MI	.15	CARBONYL G/NI	.005
•		ALCOHOL G/NI	.464
PURL ECONONY MPG	(L/100KM) 9.87 (23.84)	NNOG G/NI	.479

COMPUTER PROGRAM LOT 1.0-R

3-BAG CARB PTP VEHICLE EMISSION RESULTS PROJECT NO. 08-4527-008

	DEL	88 CHEVY CO	RSICA		RUN		METHANOL EN-1399-F FUEL DENSITY 6.620 H .126 C .375 O .4	LB/GAL
TRAKSXISSI				ACTUAL ROAD LOA				
ODOMETER		9258 NILE	S (14896 KM)	TEST WEIGHT 35	00 LBS (1587	KG)		
		2 IN HG (744 TY 44.2 PCT.		DRY BULB TEMPERATURE	70.6°F (21.	ı'c)	NOX HUNIDITY C.F	892
BAG MUNE				2	3			
BAG DESC	PIPI			STABILIZED (505-1372 SBC.)			BACKGROUND	
FORMALDI	HYDE	•	•	•	,	,		
PPN			.363	.015	.013		.017	
HASS	KG		56.32	.00	.00			
ACETALDI								
PPN			.012	.003	.001		.002	
WASS	ĦĠ		2.36	.43	.00			
ACROLEI								
PPN			.000	.000	.000		.000	
mass	MG		.00	.00	.00			
ACETONE								
PPM			.043	.008	.015		.005	
Wass	HG		12.14	1.85	3.09			
PROPION	ALDEH	YDE						
PPM			.000	.000	.000		.000	
MASS	NG		.00	.00	.00			
CROTONA	LDEHY	DE						
PPN			.000	.000	.000		.000	
MASS	NG		.00	.00	.00			
ISOBUTY	R÷MEK							
PPH			.007	.001	.001		.001	
MASS	NG		2.61	.14	.10			
BENSALD	EHYDE							
PPM			.000	.000	.000		.000	
KASS	MG		.00	.00	.00			
HEXANAL	DEHYD	E						
PPM			.000	.000	.000		.000	
HASS			.00	.00	.00.			
METHANO	L							
PPN			46.346	.274	.209		.284	
EASS		7	975.38	.00	.00			
ETHANOL	•							
PPH			.000	.000	.000		.000	
MASS	NG		.00	.00	.00			
3-BAG COM	POSI1	R RESULTS						
		FORMALDEHYDE	NG/HI	3.276	CROTONALD.	NG/NI	.000	
		ACETALDEHYDE	NG/NI	.196	ISOBUTYR+NEK		.179	
		ACROLEIN	NG/NI	.000	BENZALDEHYDE		.000	
	•	ACETONE	HG/NI	1.194	HEXANALDEHYDE		.000	
		PROPIONALD.		.000	METHANOL	MG/NI	463.908	
					ETHANOL	NG/HI	.000	

FAX COVER LETTER

DATE: <u>02/19/93</u>						
PLEASE DELIVER TO	; Mr. J	esse Jone				•
FAX NUMBER:	806-742-35	40		•		
FROM: Kevin W	itney, Phone: 2	10-522-58	869	SWRI CHA	RGE NO.	_08#
Southwest Research In Department of Emission Automotive Products of Fax Number (512) 522	ons Research and Emissions Res	search Divi	ision			
WE ARE TRANSMITT	ING <u>5</u>	_ PAGES	(includi	ing this cove	r page)	
If transmission is not com	plete, please call (5	12) 522-260)9			
MESSAGE:						

Dear Jesse:

Sorry it took me a while to get around to this. Here are copies of the emissions data from the two tests you ran. After going over the data, I feel the low NOx number in bag 2 on the test CC-TT-02 is valid. The NOx level was probably low enough that instrumentation variability caused the background bag to read higher than the sample bag. This especially makes sense when you look at the data from the previous test (CC-TT-01). NOx was very low in bag 2 on that test, also. If you have any questions, feel free to call me at 210-522-5869.

Sincerely,

Kevin A. Whitney

Engineer

Department of Emissions Research

COMPUTER PROGRAM LDT 1.0-R 3-BAG CARB FTP VEHICLE EMISSION RESULTS PROJECT NO. 08-4527-008

VERICLE NUMBER VERICLE NODEL 88 CHEVY CORSICA ENGINE 2.8 L (171 CID)-V-6 TRANSHISSION ODONKFER 14896 KM (9258 HILES)	TEST CC-TT-02 DATE 1/20/93 DYNO 2 RA ACTUAL ROAD LOA TEST WEIGHT 15	RUN AG CART 2 AD 5.74 KW (7.70 HP) 587 KG (3500 LBS)	METHANOL EM-1399-F FUEL DENSITY 6.620 LB/GAL H .126 C .375 O .499 X .000
BAROMRTER 744.7 NN HG (29.32 IN HG) RELATIVE HUNIDITY 44.2 PCT. BAG NUMBER BAG DESCRIPTION RUN TIME SECONDS DRY/WET CORRECTION FACTOR, SAMP/BACK MEASURED DISTANCE KN (MILES) BLOWER FLOW RATE SCHM (SCFM) GAS METER FLOW RATE SCHM (SCFM) TOTAL FLOW SCN (SCF)	DRY BULB TEMPERATURE	21.1°C (70.0°F)	NOX HUMIDITY C.F892
DIC MEMORY	1	,	2
BIC DECADIDATOR	CULTA MADTRELEMA	971871.7780	HAT TO MCTONT
DEG INDUKTI IIVM	(N=505 SPC)	(505±1372 SRC \	(A- RAR SEC)
RIN THE SECONDS	505.3	\$67.7	507.1
DRY/WET CORRECTION FACTOR, SAMP/BACK	.976/ 989	9797.989	.977/.989
WRASHED DISTANCE KN (WILES)	5.74 (3.57)	6.15 (3.82)	5.74 / 3.571
RIGHER PLOW RAPE SONE (SCEN)	15 79 (557 5)	15 78 (557 1)	15.76 (556.6)
CAS NETER FLOW PARK SCHW (SCHW)	01 (27)	01 (27)	01 (27)
TOTAL FLOW CON (COR)	133 0 (4697)	228 3 / 8061)	133 3 (4706)
TOTAL TENA DOUG (SOL)	133.0 (4877.)	220.3 (6001.)	133.3 (4700.)
HC SAMPLE METER/RANGE/PPM (BAG) HC BCKGRD METER/RANGE/PPM CO SAMPLE METER/RANGE/PPM CO BCKGRD METER/RANGE/PPM CO2 SAMPLE METER/RANGE/PCT CO2 BCKGRD METER/RANGE/PCT MOX SAMPLE METER/RANGE/PDM (RAG) (D)	46.07 27.45.97	12 17 27 12.09	12.17 27.12.09
HC BCKGRD NETER/RANGE/PPM	9.4/ 2/ 9.39	11.0/ 2/ 10.99	10.7/ 2/ 10.69
CO SAMPLE METER/RANGE/PPM	58.1/ 12/ 56.81	13.6/ 12/ 13.06	31.8/ 12/ 11.32
CO BCKGRD NETER/RANGE/PPN	2.9/ 12/ 2.76	2.3/ 12/ 2.19	2.7/ 12/ 2.57
CO2 SAMPLE NETER/RANGE/PCT	77 5/ 14/ 6152	67 7/ 14/ 4680	74 7! 14/ 5695
CO2 BCKGRD METER/RANGE/PCT	14.4/ 14/ .0494	14.5/ 14/ .0498	14.9/ 14/ .0515
NOX SAMPLE METER/RANGE/PPM (BAG) (D)	39.9/ 1/ 9.97	1.5/ 1/ .38	7.8/ 1/ 1.96
NOX BCKGRD WETER/RANGE/PPW	2.3/ 1/ 58	3 1/ 1/ 78	1.0/ 1/ 25
CH4 SANPLE PPN (1.120)	4.36	3 90	4.77
CO2 BCKGRD NETER/RANGE/PCT NOX SAMPLE NETER/RANGE/PPM (BAG) (D) NOX BCKGRD NETER/RANGE/PPM CH4 SAMPLE PPM (1.120) CH4 BCKGRD PPM DILUTION FACTOR HC CONCENTRATION PPM CO2 CONCENTRATION PPM CO2 CONCENTRATION PCT NOX CONCENTRATION PPM CH4 CONCENTRATION PPM HNHC CONCENTRATION PPM	3.30	3.18	3.12
DILUTION FACTOR	18.47	24.58	20.23
HC CONCENTRATION PPH	37.09	1.55	1.93
CO CONCENTRATION PPN	52.38	10.63	8.56
CO2 CONCENTRATION PCT	.5685	.4202	.5206
NOX CONCENTRATION PPM	9.42	37	1.72
CH4 CONCENTRATION PPN	.98	. 85	1.80
HIGHC CONCENTRATION PPH	.00	. 59	04
THC NASS GRAMS	8.136	.210	.163
CO MASS GRAMS	8.112	2.824	1.328
CO2 NASS GRANS	1384.57	1756.07	1270.27
NOX HASS GRAMS	2.139	.000	.391
CH4 MASS GRANS	.087	. 130	.160
NORC MASS GRAMS (FID)	.000	.078	.000
FUEL HASS KG	1.025	1.282	.926
FUEL BOOROHY L/100KU (MPG)	22.51 (10.45)	26.26 (8.96)	20.35 (11.56)
3-BAG COMPOSITE RESULTS			
THC G/NI	.48 CH4 G/	/NT .03	
CO G/NI		/NT .01	
NOX G/MI	.15 CARBONYL G		
· -·· — -; -·-	· · · · · · · · · · · · · · · · · · ·	ALCOHOL G/MI	.46
FUEL ECOHOMY MPG (L/100KM) 9.	87 (23.84)	NMOG G/MI	.479

VEHICLE NUMBER 577

COMPUTER PROGRAM LDT 1.0-R 3-BAG CARB FTP VEHICLE BHISSION RESULTS PROJECT NO. 08-4527-008

TEST CC-TT-02

METRANOL EM-1399-F

	VEHICLE HODEL 88 CHEVY CORSICA ENGINE 2.8 L (171 CID)-V-6		DATE 1/20/93 RUN DYNO 2 BAG CART 2			FUEL DENSITY 6.620 LB/GAL		
						126 C .375 O	.499 X .000	
TRANSMISSION				D 5.74 KW (7.70 HF	?)			
ODONETER	14896	KM (9258 MILES)	TEST WEIGHT 15	587 KG (3500 LBS)				
BAROMETER 744.7	FIN HG	(29.32 IN HG)	DRY BULB TEMPERATURE	21.1°C (70.0°F)	NON	HUNIDITY C.F.	.892	
RELATIVE HUNIDI	TY 44.2	PCT.						
BAG MURBER		1	2	3				
BAG DESCRIPT	EOM	COLD TRANSIENT	STABILI 7RD	HOT TRANSIENT	Back	(GROUND		
		(0-505 SEC.)	(505-1372 SEC.)	(0- 505 SEC.)				
PORKALDERYDE								
PPW		.363	.015	.013		.017		
MASS ING		56.32	.00	.00				
ACETALDEHYDE								
PPN		.012	.003	.001		.002		
NASS NG		2.36	.43	. 00				
ACROLEIN								
PPM		.000	.000	,000		.000		
NASS MG		.00	.00	.00				
ACETONE							-	
PPH		.043	.008	.015		.005		
NASS NG		12.14	1.85	3.09				
PROPIONALDEH	YDF	,	2	•••				
PPK	102	.000	.000	.000		.000		
WASS MG		.00	.00	.00				
CROTOBALDEHY	N.F	.50	.00	•00				
PPH	V LI	.000	.000	.000		.000		
NASS NG		.00	.00	.00		.000		
ISOBUTYR+NEK		.00	.00	.00				
PPH		.007	001	.001		001		
			.001	.10		.001		
HASS NG BENZALDENYDE	1	2.61	.14	.10				
	•	^	000	000		000		
PPN No. of No.		.000	.000	.000		.000		
MASS NG	Æ	.00	.00	.00				
HKXANALDEHYD	'E	000	000	000		AAA		
PPM		.000	.000	.000		.000		
NASS NG		.00	.00	.00				
METHANOL								
PPN		46.346	.274	.209		.284		
MASS ING		7975.38	.00	.00				
ETHANOL								
PPN		.000	.000	.000		.000		
MASS NG		.00	.00	.00				
3-BAG COMPOSI	ie resui	TS.						
FORMALDERYD			2.036 (3.276)	CROTONALD.	MG/KM (NO	S/NI)	.000 (.000)	
ACETALDEHYD			.122 (.196)	ISOBUTYR+NEK		· ·	.111 (.179)	
ACROLEIN		(MG/MI)	.000 (.000)	BENZALDEHYDE		•	.000 (.000)	
ACETONE		(MG/MI)	.742 (1.194)	HEXANALDEHYDE			.000 (.000)	
PROPIONALD.			.000 (.000)	METHANOL	MG/KM (M	•	288.321 (463.908)	
	-,	· ···, (ETHANOL	NG/KN (N		.000 (.000)	
					, /14	-,	()	

COMPUTER PROGRAM LDT 1.0-R 3-BAG CARB FTP VEHICLE EMISSION RESULTS PROJECT NO. 08-4527-008

VEHICLE NUMBER VEHICLE NODEL ENGINE	577 88 CHEVY CORSICA 2.8 L (171 CID)-V-6	TEST CC-TT-01 DATE 1/19/93 DYNO 2 B	RUN AG CART 2	METRANOL EM-1399-P FUEL DENSITY 6.620 LB/GAL H .126 C .375 O .499 X .000
TRANSMISSION ODONETER	5N 14896 KM (9258 MILES)	ACTUAL ROAD LO TEST WEIGHT 1	AD 5.74 KW (7.70 HP) 587 KG (3500 LBS)	
7100W7FT 044 A			70 3 ³ 0 (70 6 ⁹ E)	VAU MITUTATING A E AAA
RIG MIWARP	., 50.0 101.	1	2	3
BAG DESCRIPTION	ON	COLD TRANSIENT	STABILIZED	HOT TRANSIENT
	~3.	(0-505 SBC.)	(505-1372 SBC.)	(0- 505 SEC.)
RUN TIME SECO	NDS	505.2	867. 0	505.4
DRY/WET CORRE	CTION FACTOR, SAMP/BACK	.977/.989	.980/.989	.978/.989
MEASURED DIST	ANCE KN (MILES)	5.76 (3.58)	6.16 (3.83)	5.74 (3.57)
BLOWER FLOW R	ATE SCHN (SCFN)	15.78 (557.2)	15.77 (556.9)	15.76 (556.5)
GAS NETER FLO	W RATE SCHOL (SCPH)	.01 (.27)	01 (.27)	.01 (.27)
TOTAL FLOW SC	M (SCF)	132.9 (4694.)	228.0 (8051.)	132.8 (4689.)
	• •	, ,	·	
EC SAMPLE HE	TER/RANGE/PPH (BAG)	37.8/ 2/ 37.78	11 9/ 2/ 11.89	11.5/ 2/ 1 47
HC BCKGRD HE	TER/RANGE/PPN	7.6/ 2/ 7.60	9 9/ 2/ 9.89	9.7/ 2/ ÷.69
co sample ne	TER/RANGE/PPM	33.6/ 12/ 32.60	17 1/ 12/ 16.47	10.6/ 12/ 10.16
OO BOKGRD HE	TER/RANGE/PPH	1.1/ 12/ 1.04	1 4/ 12/ 1.33	1.3/ 12/ 1.23
CO2 SAMPLE HE	ETER/RANGE/PCT	77.8/ 14/ .6203	67.4/ 14/ .4640	74.1/ 14/ .5601
CO2 BCKGRD KE	RTER/RANGE/PCT	14.0/ 14/ .0478	13 7/ 14/ .0466	13.8/ 14/ .0470
HOX SAMPLE NI	ETER/RANGE/PPM (BAG) (D)	45.8/ 1/ 11.43	2.7/ 1/ .68	27.0/ 1/ 6.77
NOX BOKGRD NI	rter/range/ppn	1.5/ 1/ .38	1.9/ 1/ .48	1.1/ 1/ .28
CH4 SAMPLE PI	PR (1.120)	4.29	3 .55	4.39
CH4 BCKGRD PI	PN	2.54	2.52	2.51
DILUTION FAC	TER/RANGE/PPH (BAG) TER/RANGE/PPH TER/RANGE/PPH TER/RANGE/PPH TER/RANGE/PCT ETER/RANGE/PCT ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/RANGE/PPH ETER/	18.42	24.78	20.57
HC CONCENTI	RATION PPM	30.5 9	2.40	2.27
CO CONCENT	RATION PPN	30.61	14.77	8.70
CO2 CONCENT	RATION PCT	.5 751	. 4193	.5154
NOX CONCENT	RATION PPN	11.07	.22	6.51
CH4 CONCENT	RATION PPN	1.88	1.13	2.60
NAME CONCENT	RATION PRN	.13	1.07	.02
THC NASS	GRAMS	6.521	. 365	.189
OO MASS		4.737	3.920	1.345
CO2 MASS		1399.64	1750.06	1253.19
NOX MASS		2.478	.085	1.454
CH4 HASS		.167	.172	.178
	GRAMS (FID)	.010	.141	.001
FUEL NASS		1.031	1.279	.914
FUEL ECONORY	! L/100KOK (NDPG)	22.55 (10.43)	26.18 (8.98)	20.08 (11.71)
3-BAG COMPOSIT	TE RESULTS			
	THC G/MI		S/NI .05	
	CO G/MI		G/MI .02	
	HOX G/NI	.27 CARBONYL (G/NI .01	
			ALCOHOL G/NI	.37
PUEL ECONOM	Y NPG (L/100KM) 9	.91 (23.73)	NINOC C/NI	.396

COMPUTER PROGRAM LOT 1.0-R

3-BAG CARB FTP VEHICLE EMISSION RESULTS PROJECT NO. 08-4527-008

VEHICLE MODEL ENGINE TRANSMISSION	ER 577 L 88 CHEVY CORSICA 2.8 L (171 CID)-V-6 5N 14896 KK (9258 MILES)		DYNO 2 BÀ ACTUAL ROAD LOA	RUN G CARM 2 D 5.74 KW 7.70 HP		620 LB/GAL
BAROMETER 744. RELATIVE HUNID			DRY BULB TEMPERATURE	22.2°C (72.0°F)	NON HUNIDITY C.	680
		1	2	3		
BAG DESCRIPT		COLD TRANSIENT	STABILIZED (505-1372 SEC.)	HOT TRANSIENT	BACKGROUND	
FORMALDEHYDE						
PPH		.252	.008	.011	.014	
MASS NG		38.71	.00	.00		
ACETALDEHYDE						
PPH		.035	.015	.005	.002	
MASS HG		7.83	5.54	.øţ		
ACROLEIN				•••	•••	
PPN		.015	.000	.000	.000	
NASS NG		4.39	.00	.00		
ACETONE		6.40	25.		22.	
PPK		.048	.059	.036	.013	
MASS NG	nan r	11.22	25.06	7.5		
PROPIONALDE	NYUL	01.1	ânn	200	νω.	
PPN Mass ng		.010	.000	.990 .90	.000	
	ALIVE.	3.13	.00	NU s		
CROTONALDEH PPH	IJĘ	.000	.000	ann	.000	
MASS NG		.00	.00	.000 .00	.000	
ISOBUTYR+KE	7	.00	.00	. ()		
PPM	V	.000	.001	.000	.001	
MASS MG		.00	.04	.00	1001	
BENZALDEHYD	F	•••	• (7)	700		
PPN	_	.000	.000	.300	.000	
MASS NG		.90	.00	.00	.000	
HEXANALDENY	יבע	•00	.00	. 000		
PPM	-	.000	.000	.000	.000	
MASS NG		.(0)	,()()	.00		
METHANOL			,,,			
PPM		36.444	. 238	.1 7 3	.171	
MASS MG		6279.27	21.59	1.45		
ETHANOL						
PPM		.000	.000	.000	.000	
MASS NG		.00	.00	.00		
3-BAG COMPOSI	HE RESU	AS				
FORMALDEHYT			1.396 (2.247)	CRGTONALD.	MG/KM (MG/MI)	(000.)
ACETALDEBY			.779 (1.253)		NG/KN (NG/NI)	.003 (.005)
ACROLEIN		(MG/MI)	.158 (.255)		MG/KM (MG/MI)	(000.) 000.
ACETONE		(MG/NI)	2.872 (4.622)		MG/KH (MG/HI)	.000 (.000)
PROPIONALD			.113 (.182)	METHANOL	MG/KM (MG/MI)	228.389 (367.478)
		- ,		ETHANOL	MG/KM (MG/NE)	(000.) 000.
					, , ,	

SOUTHWEST RESEARCH INSTITUTE

-120001EBAA ROAD . POST OFFICE ORAWER 28510 . SAN ANTONIO TEXAS USA 78228-0510 . (210) 684-5111 . TELEX 244846

FAX COVER LETTER

	DATE: 11/arck 31, 1995
PLEASE DELIVER TO: Jesse Jor	veS
COMPANY/FIRM: TEXAS TECK	
FAX NUMBER: 806-742-35	540
FROM: Kevin Whitney	SWRI CHARGE NO.
Southwest Research Institute Department of Emissions Research Automotive Products and Emissions Re	
FAX NUMBER (210) 522-3950	
WE ARE TRANSMITTING PA	
MESSAGE:	



To: Jesse Jones Texas Tech

> 806-742-3563 voice 806-742-3540 FAX

From: Kevin Whitney

Southwest Research Institute

210-522-5869 voice

Jesse,

Attached are 6 pages of test data from your Corsica. The data has been processed according to CARB methodology, so there are no OMHCE numbers. The NMOG numbers are calculated using the FID results for the gasoline portion of the exhaust. The initial tests in January 93 are CC-TT-01 and CC-TT-02. The test after mileage is TECH12/94. On the 12/94 test we had extreme difficulty on the cold start. The vehicle had to be cranked about 15 seconds, and it ran rough while in open-loop.

The data from the 12/94 test shows higher emissions for all exhaust components over all 3 bags of the FTP. In addition, fuel economy is only slightly lower on this test than previous tests. I suspect this is an indication of a failed catalyst.

Please feel free to call me at the voice number listed above if you have further questions.

Sincerely,

WEN

Kevin Whitney

COMPUTER PROGRAM LDT 1.2-R

3-BAG CARB FTP VEHICLE EMISSION RESULTS

PROJECT NO. 08-6761-004

.000

TEST TENTICLE BUMBLE 657 TRIST TENTICL/94 TRIVERIOR BUMBLE 21.5 L (171 CID)-17-6 DATE 12/16/94 TRIVERIOR BUMBLE 21.5 L (171 CID)-17-6 DATE 12/16/94 TRIVERIOR BUMBLE 21.5 L (171 CID)-17-6 ACTUAL ROAD DADD 7.70 SP (5.74 KR) TOUR DESISTY 6.620 LB/GAL PM CONCETTER 30943 MILES (49851 KR) DEV BULLE TEMPERATURE 68.0° F (20.0° C) MOX BUMBUTY C.F. 1.048	VERICLE BUNBER VERICLE BODEL	577 88 CBEVY	CORSICA		TEST TECH12/ DATE 12/16/9	94 4 RUN		METHA!	NOL M85 DENSITY 6.	AS RECEIV 620 LB/GAL
BANGERTER 29.32 IN BG (744.7 NR BG) DRY BULE YEMPERATURE 68.0 F (20.0 °C) NOX BUNIDITY C.F. 1.048	ENGINE	2.8 L (17	1 CID)-V-0	5	DYNO 2	BAG CARI 2		H .12	5 C .375 (0 .499 X .000
BANGERTER 29.32 IN BG (744.7 NR BG) DRY BULE YEMPERATURE 68.0 F (20.0 °C) NOX BUNIDITY C.F. 1.048	TRANSMISSION	115			ACTUAL ROAD	LOAD 7.70 H	P (5.74 K	₩)		
EMERITE 29.32 IN BG (744.7 NR HG)	ODONETER	30983 NI	LES (498	51 KM)	TEST WEIGHT	3500 LBS ()	1587 KG)			
BK SAMPLE NETER/KARNE/PPH 5.7/ 2/ 5.70 5.3/ 2/ 5.00 4.7/ 2/ 4.70							•			
BK SAMPLE NETER/KARNE/PPH 5.7/ 2/ 5.70 5.3/ 2/ 5.00 4.7/ 2/ 4.70	BAG MUMBER				1	2		3		
BK SAMPLE NETER/KARNE/PPH 5.7/ 2/ 5.70 5.3/ 2/ 5.00 4.7/ 2/ 4.70	BAG DESCRIPT	ION		COL	D TRANSIENT	STABIL	IZED	hot tran	SIENT	
BK SAMPLE NETER/KARNE/PPH 5.7/ 2/ 5.70 5.3/ 2/ 5.00 4.7/ 2/ 4.70				(0-505 SEC.)	(505-137)	2 SEC.)	(0- 50	5 SEC.)	
BK SAMPLE NETER/KARNE/PPH 5.7/ 2/ 5.70 5.3/ 2/ 5.00 4.7/ 2/ 4.70	RUN TIME SEC	ONEDS			505.5	867.	2	505. 7		
BK SAMPLE NETER/KARNE/PPH 5.7/ 2/ 5.70 5.3/ 2/ 5.00 4.7/ 2/ 4.70	DRY/WET CORR	ECTION FACE	OR, SAMP/	BACK .	968/.981	.972/.	981	.970/.9	81	
BK SAMPLE NETER/KARNE/PPH 5.7/ 2/ 5.70 5.3/ 2/ 5.00 4.7/ 2/ 4.70	NEASURED DIS	PANCE MILES	(KM)	3.	61 (5.80)	3.84 (6.18)	3 .58 (5	.77)	
BK SAMPLE NETER/KARNE/PPH 5.7/ 2/ 5.70 5.3/ 2/ 5.00 4.7/ 2/ 4.70	BLOWER FLOW	rate scen (SCION)	56	5.4 (16.01)	567. 2 (16.06)	562.9 (1	5.94)	
BK SAMPLE NETER/KARNE/PPH 5.7/ 2/ 5.70 5.3/ 2/ 5.00 4.7/ 2/ 4.70	CAS METER FU	ow rate sci	M (SCHM)	•	27 (.01)	.28 (.01)	.28 (.01)	
BK SAMPLE NETER/KARNE/PPH 5.7/ 2/ 5.70 5.3/ 2/ 5.00 4.7/ 2/ 4.70	TOTAL FLOW S	CF (SCH)		476	6. (135.0)	8202.	232.3)	4747. (1	34.4)	
THC HASS GRAMS CO MASS GRAMS 32.166 9.494 14.906 CO2 MASS GRAMS 1538.14 1739.54 1225.11 MOX HASS GRAMS 3.535 1.471 3.746 CH4 MASS GRAMS 609 .766 .706 MUNIC HASS GRAMS 1.174 1.278 .910 FUEL BOOMONY MPG (L/100KM) 9.23 (25.50) 9.02 (26.08) 11.83 (19.89) 3-BAG COMPOSITE RESULTS THC G.RI 1.167 CH4 G/MI .193 CO G/MI 4.280 MUNIC G/MI .004 MOX G/MI .690 CARBONYL G/MI .022 ALCOHOL G/MI .948	BC SAMPLE N	eter/range/	PPM (BAG)	82.5	<i>j</i> 2 <i>j</i> 82.45	10.9/ 2	/ 10.89	14.5/ 2/	14.49	
THC HASS GRAMS CO MASS GRAMS 32.166 9.494 14.906 CO2 MASS GRAMS 1538.14 1739.54 1225.11 MOX HASS GRAMS 3.535 1.471 3.746 CH4 MASS GRAMS 609 .766 .706 MUNIC HASS GRAMS 1.174 1.278 .910 FUEL BOOMONY MPG (L/100KM) 9.23 (25.50) 9.02 (26.08) 11.83 (19.89) 3-BAG COMPOSITE RESULTS THC G.RI 1.167 CH4 G/MI .193 CO G/MI 4.280 MUNIC G/MI .004 MOX G/MI .690 CARBONYL G/MI .022 ALCOHOL G/MI .948	EC BOKGRD N	ETER/RANGE	PPN	5.7	/ 2/ 5.70	5.3/ 2	/ 5.30	4.7/ 2/	4.70	
THC HASS GRAMS CO MASS GRAMS 32.166 9.494 14.906 CO2 MASS GRAMS 1538.14 1739.54 1225.11 MOX HASS GRAMS 3.535 1.471 3.746 CH4 MASS GRAMS 609 .766 .706 MUNIC HASS GRAMS 1.174 1.278 .910 FUEL BOOMONY MPG (L/100KM) 9.23 (25.50) 9.02 (26.08) 11.83 (19.89) 3-BAG COMPOSITE RESULTS THC G.RI 1.167 CH4 G/MI .193 CO G/MI 4.280 MUNIC G/MI .004 MOX G/MI .690 CARBONYL G/MI .022 ALCOHOL G/MI .948	CO SAMPLE M	ETER/RANGE,	/PPK	88.0	/ 13/ 214.97	37.6/ 12	/ 36.74	43.6/ 13/	99.87	
THC HASS GRAMS CO MASS GRAMS 32.166 9.494 14.906 CO2 MASS GRAMS 1538.14 1739.54 1225.11 MOX HASS GRAMS 3.535 1.471 3.746 CH4 MASS GRAMS 609 .766 .706 MUNIC HASS GRAMS 1.174 1.278 .910 FUEL BOOMONY MPG (L/100KM) 9.23 (25.50) 9.02 (26.08) 11.83 (19.89) 3-BAG COMPOSITE RESULTS THC G.RI 1.167 CH4 G/MI .193 CO G/MI 4.280 MUNIC G/MI .004 MOX G/MI .690 CARBONYL G/MI .022 ALCOHOL G/MI .948	co bokgrd n	eter/range,	PPN	.2	/ 13/ .44	.2/ 12	, 20	.2/ 13/	.44	
THC HASS GRAMS CO MASS GRAMS 32.166 9.494 14.906 CO2 MASS GRAMS 1538.14 1739.54 1225.11 MOX HASS GRAMS 3.535 1.471 3.746 CH4 MASS GRAMS 609 .766 .706 MUNIC HASS GRAMS 1.174 1.278 .910 FUEL BOOMONY MPG (L/100KM) 9.23 (25.50) 9.02 (26.08) 11.83 (19.89) 3-BAG COMPOSITE RESULTS THC G.RI 1.167 CH4 G/MI .193 CO G/MI 4.280 MUNIC G/MI .004 MOX G/MI .690 CARBONYL G/MI .022 ALCOHOL G/MI .948	CO2 SAMPLE N	ETER/RANGE,	/PCT	80.2	1/ 14/ .6589	66.4/ 14	/ .4456	72.8/ 14/	.5354	
THC HASS GRAMS CO MASS GRAMS 32.166 9.494 14.906 CO2 MASS GRAMS 1538.14 1739.54 1225.11 MOX HASS GRAMS 3.535 1.471 3.746 CH4 MASS GRAMS 609 .766 .706 MUNIC HASS GRAMS 1.174 1.278 .910 FUEL BOOMONY MPG (L/100KM) 9.23 (25.50) 9.02 (26.08) 11.83 (19.89) 3-BAG COMPOSITE RESULTS THC G.RI 1.167 CH4 G/MI .193 CO G/MI 4.280 MUNIC G/MI .004 MOX G/MI .690 CARBONYL G/MI .022 ALCOHOL G/MI .948	CO2 BOKGRD N	eter/range,	/PCT	12.1	./ 14/ .0387	11.9/ 14	/ .0380	12.3/ 14/	.0395	
THC HASS GRAMS CO MASS GRAMS 32.166 9.494 14.906 CO2 MASS GRAMS 1538.14 1739.54 1225.11 MOX HASS GRAMS 3.535 1.471 3.746 CH4 MASS GRAMS 609 .766 .706 MUNIC HASS GRAMS 1.174 1.278 .910 FUEL BOOMONY MPG (L/100KM) 9.23 (25.50) 9.02 (26.08) 11.83 (19.89) 3-BAG COMPOSITE RESULTS THC G.RI 1.167 CH4 G/MI .193 CO G/MI 4.280 MUNIC G/MI .004 MOX G/MI .690 CARBONYL G/MI .022 ALCOHOL G/MI .948	nox sample n	eter/range,	/PPM (BAG)	(D) 53.2	2/ 1/ 13.22	12.9/ 1	/ 3.29	56.0/ 1/	13.91	
THC HASS GRAMS CO MASS GRAMS 32.166 9.494 14.906 CO2 MASS GRAMS 1538.14 1739.54 1225.11 MOX HASS GRAMS 3.535 1.471 3.746 CH4 MASS GRAMS 609 .766 .706 MUNIC HASS GRAMS 1.174 1.278 .910 FUEL BOOMONY MPG (L/100KM) 9.23 (25.50) 9.02 (26.08) 11.83 (19.89) 3-BAG COMPOSITE RESULTS THC G.RI 1.167 CH4 G/MI .193 CO G/MI 4.280 MUNIC G/MI .004 MOX G/MI .690 CARBONYL G/MI .022 ALCOHOL G/MI .948	noi bokeed k	eter/range,	PPK	.6	b/ 1/ .16	.5/ 1	/ .13	.0/ 1/	.00	
THC HASS GRAMS CO MASS GRAMS 32.166 9.494 14.906 CO2 MASS GRAMS 1538.14 1739.54 1225.11 MOX HASS GRAMS 3.535 1.471 3.746 CH4 MASS GRAMS 609 .766 .706 MUNIC HASS GRAMS 1.174 1.278 .910 FUEL BOOMONY MPG (L/100KM) 9.23 (25.50) 9.02 (26.08) 11.83 (19.89) 3-BAG COMPOSITE RESULTS THC G.RI 1.167 CH4 G/MI .193 CO G/MI 4.280 MUNIC G/MI .004 MOX G/MI .690 CARBONYL G/MI .022 ALCOHOL G/MI .948	CEA SAMPLE P	PM (1.160)			8.9 0	7.	20	10.22	!	
THC HASS GRAMS CO MASS GRAMS 32.166 9.494 14.906 CO2 MASS GRAMS 1538.14 1739.54 1225.11 MOX HASS GRAMS 3.535 1.471 3.746 CH4 MASS GRAMS 609 .766 .706 MUNIC HASS GRAMS 1.174 1.278 .910 FUEL BOOMONY MPG (L/100KM) 9.23 (25.50) 9.02 (26.08) 11.83 (19.89) 3-BAG COMPOSITE RESULTS THC G.RI 1.167 CH4 G/MI .193 CO G/MI 4.280 MUNIC G/MI .004 MOX G/MI .690 CARBONYL G/MI .022 ALCOHOL G/MI .948	CEN BOKGED P	?K			2.27	2.	34	2.45		
THC HASS GRAMS CO MASS GRAMS 32.166 9.494 14.906 CO2 MASS GRAMS 1538.14 1739.54 1225.11 MOX HASS GRAMS 3.535 1.471 3.746 CH4 MASS GRAMS 609 .766 .706 MUNIC HASS GRAMS 1.174 1.278 .910 FUEL BOOMONY MPG (L/100KM) 9.23 (25.50) 9.02 (26.08) 11.83 (19.89) 3-BAG COMPOSITE RESULTS THC G.RI 1.167 CH4 G/MI .193 CO G/MI 4.280 MUNIC G/MI .004 MOX G/MI .690 CARBONYL G/MI .022 ALCOHOL G/MI .948	DILUTION FAC	TOR			16.78	2	5.69	21	.17	
THC HASS GRAMS CO MASS GRAMS 32.166 9.494 14.906 CO2 MASS GRAMS 1538.14 1739.54 1225.11 MOX HASS GRAMS 3.535 1.471 3.746 CH4 MASS GRAMS 609 .766 .706 MUNIC HASS GRAMS 1.174 1.278 .910 FUEL BOOMONY MPG (L/100KM) 9.23 (25.50) 9.02 (26.08) 11.83 (19.89) 3-BAG COMPOSITE RESULTS THC G.RI 1.167 CH4 G/MI .193 CO G/MI 4.280 MUNIC G/MI .004 MOX G/MI .690 CARBONYL G/MI .022 ALCOHOL G/MI .948	BC CONCENT	RATION PPH			77.10		5.80	10	.02	
THC HASS GRAMS CO MASS GRAMS 32.166 9.494 14.906 CO2 MASS GRAMS 1538.14 1739.54 1225.11 MOX HASS GRAMS 3.535 1.471 3.746 CH4 MASS GRAMS 609 .766 .706 MUNIC HASS GRAMS 1.174 1.278 .910 FUEL BOOMONY MPG (L/100KM) 9.23 (25.50) 9.02 (26.08) 11.83 (19.89) 3-BAG COMPOSITE RESULTS THC G.RI 1.167 CH4 G/MI .193 CO G/MI 4.280 MUNIC G/MI .004 MOX G/MI .690 CARBONYL G/MI .022 ALCOHOL G/MI .948	CO CONTROL	RATION PPN			204.71	3	5.11	95	.25	
THC HASS GRAMS CO MASS GRAMS 32.166 9.494 14.906 CO2 MASS GRAMS 1538.14 1739.54 1225.11 MOX HASS GRAMS 3.535 1.471 3.746 CH4 MASS GRAMS 609 .766 .706 MUNIC HASS GRAMS 1.174 1.278 .910 FUEL BOOMONY MPG (L/100KM) 9.23 (25.50) 9.02 (26.08) 11.83 (19.89) 3-BAG COMPOSITE RESULTS THC G.RI 1.167 CH4 G/MI .193 CO G/MI 4.280 MUNIC G/MI .004 MOX G/MI .690 CARBONYL G/MI .022 ALCOHOL G/MI .948	OO2 CONCERT	TATION PCT			.6225		4090	.4	978	
THC HASS GRAMS CO MASS GRAMS 32.166 9.494 14.906 CO2 MASS GRAMS 1538.14 1739.54 1225.11 MOX HASS GRAMS 3.535 1.471 3.746 CH4 MASS GRAMS 609 .766 .706 MUNIC HASS GRAMS 1.174 1.278 .910 FUEL BOOMONY MPG (L/100KM) 9.23 (25.50) 9.02 (26.08) 11.83 (19.89) 3-BAG COMPOSITE RESULTS THC G.RI 1.167 CH4 G/MI .193 CO G/MI 4.280 MUNIC G/MI .004 MOX G/MI .690 CARBONYL G/MI .022 ALCOHOL G/MI .948	NOI CONCENT	RATION PPH			13.07		3.16	13	3.91	
THC HASS GRAMS CO MASS GRAMS 32.166 9.494 14.906 CO2 MASS GRAMS 1538.14 1739.54 1225.11 MOX HASS GRAMS 3.535 1.471 3.746 CH4 MASS GRAMS 609 .766 .706 MUNIC HASS GRAMS 1.174 1.278 .910 FUEL BOOMONY MPG (L/100KM) 9.23 (25.50) 9.02 (26.08) 11.83 (19.89) 3-BAG COMPOSITE RESULTS THC G.RI 1.167 CH4 G/MI .193 CO G/MI 4.280 MUNIC G/MI .004 MOX G/MI .690 CARBONYL G/MI .022 ALCOHOL G/MI .948	CE4 CONCENT	RATION PPN			6.77		4.95	7	.88	
THC HASS GRAMS CO MASS GRAMS 32.166 9.494 14.906 CO2 MASS GRAMS 1538.14 1739.54 1225.11 MOX HASS GRAMS 3.535 1.471 3.746 CH4 MASS GRAMS 609 .766 .706 MUNIC HASS GRAMS 1.174 1.278 .910 FUEL BOOMONY MPG (L/100KM) 9.23 (25.50) 9.02 (26.08) 11.83 (19.89) 3-BAG COMPOSITE RESULTS THC G.RI 1.167 CH4 G/MI .193 CO G/MI 4.280 MUNIC G/MI .004 MOX G/MI .690 CARBONYL G/MI .022 ALCOHOL G/MI .948	NIMBE CONCENT	RATION PPH			-3.33		.06		.55	
CO MASS GRAMS 32.166 9.494 14.906 CO2 MASS GRAMS 1538.14 1739.54 1225.11 MOX MASS GRAMS 3.535 1.471 3.746 CH4 MASS GRAMS 609 .766 .706 MUNIC MASS GRAMS (FID) .000 .008 .043 FUEL MASS KG 1.174 1.278 .910 FUEL ECOMONY MPG (L/100KN) 9.23 (25.50) 9.02 (26.08) 11.83 (19.89) 3-BAG COMPOSITE RESULTS TBC G-NI 1.167 CH4 G/MI .193 CO G/MI 4.280 MMHC G/MI .004 MOI G/NI .690 CARBONYL G/MI .022 ALCOHOL G/MI .948	THC HASS	GRAMS								
CO2 MASS GRAMS 1538.14 1739.54 1225.11 MOX MASS GRAMS 3.535 1.471 3.746 CH4 MASS GRAMS .609 .766 .706 MUNIC MASS GRAMS (FID) .000 .008 .043 FUEL MASS KG 1.174 1.278 .910 FUEL ECOMONY MPG (L/LOOK) 9.23 (25.50) 9.02 (26.08) 11.83 (19.89) 3-BAG COMPOSITE RESULTS THC G.RI 1.167 CH4 G/MI .193 CO G/MI 4.280 MUNIC G/MI .004 MOI G/MI .690 CARBONYL G/MI .022 ALCOHOL G/MI .948										
HOX HASS GRAMS 3.535 1.471 3.746										
CH4 MASS GRAMS	NOX MASS	GRANS								
FUEL MASS KG 1.174 1.278 .910 FUEL ECOMONY MPG (L/100KM) 9.23 (25.50) 9.02 (26.08) 11.83 (19.89) 3-BAG COMPOSITE RESULTS THC G.MI 1.167 CH4 G/MI .193 CO G/MI 4.280 MMHC G/MI .004 MOI G/MI .690 CARBONYL G/MI .022 ALCOHOL G/MI .948	CH4 MASS	GRANS			.609		.766	•	706	
FUEL ECONOMY NPG (L/100KM) 9.23 (25.50) 9.02 (26.08) 11.83 (19.89) 3-BAG COMPOSITE RESULTS THC G.MI 1.167 CH4 G/MI .193 CO G/MI 4.280 MMHC G/MI .004 MOI G/MI .690 CARBONYL G/MI .022 ALCOHOL G/MI .948)		.000		.008	. (043	
3-BAG COMPOSITE RESULTS THC G.RI 1.167 CH4 G/MI .193 CO G/MI 4.280 MMHC G/MI .004 MOI G/MI .690 CARBONYL G/MI .022 ALCOHOL G/MI .948	fuel mass	KG			1.174	1.	.278	.9	10	
THC G.NI 1.167 CH4 G/MI .193 CO G/MI 4.280 NMHC G/MI .004 HOI G/NI .690 CARBONYL G/MI .022 ALCOHOL G/MI .948	FUEL ECONON	Y 10PG (L/10	OK(N)		9.23 (25.50)	9.02	(26.08)	11.83 (19.89)	
CO G/MI 4.280 NMHC G/MI .004 MOX G/MI .690 CARBONYL G/MI .022 ALCOHOL G/MI .948	3-BAG COMPOSIS	TE RESULTS	;							
CO G/MI 4.280 NMHC G/MI .004 MOX G/MI .690 CARBONYL G/MI .022 ALCOHOL G/MI .948		TEC	G. NI	1.167		CH4	G/MT	.193		
MOI G/RI .690 CARBONYL G/MI .022 ALCOHOL G/MI .948										
ALCOHOL G/MI .948							,			
ι				• • • •			•			
·		FUEL	ECONOMY N	PG (L/100KK)	9.73 (24.1		•		RAF=1.00)	

COMPUTER PROGRAM LDT 1.2-R 3-BAG CARB FTP VEHICLE EMISSION RESULTS PROJECT NO. 08-6761-004

VERICLE NUMBI VERICLE NODEL ENGINE TRANSMISSION ODORETER	ER 577 L 88 CHEVY CC 2.8 L (171 M5 30983 HILE	ORSICA CID)-V-6 ES (49851 KM)	TEST TECH12/94 DATE 12/16/94 RUN DYNO 2 BAG CART 2 ACTUAL ROAD LOAD 7.70 HP (5.74 KW) TEST WEIGHT 3500 LBS (1587 KG)			METHANOL N85 AS RECEIV FUEL DENSITY 6.620 LB/GAL H .126 C .375 O .499 X .000		
			DRY BULB TEMPERATURE	68.0°F (20.0)*C)	NOX HUMIDITY C.F. 1.048		
	IDITY 80.7 PCT.							
BAG NUMBER		1	2 STABILIZED	3				
BAG DESCRI	PTION COL	D TRANSIENT	STABILIZED	HOT TRANSIE	THE	BACKGROUND		
		0-505 SEC.}	(505-1372 SEC.)	(0- 505 3	SEC.)			
PORNALDERY		2 122	010	01.5		000		
PPW		2.127	.012			.009		
MASS NO		345.48	.76	.52				
ACETALDERY		ne:	^	.000		.001		
PPR NASS NG		.051 11.87	.001 .00	.00		.001		
ACROLEIN		11.07	.00	.00				
PPN		.000	.000	.000		.000		
NASS NG		.00	.00	.00		,000		
ACETONE		-00	•••	.00				
PPM		.020	.005	.026		.007		
MASS NG		4.32	.00	5.95		•••		
PROPIONALD		1102		3173				
PPM		.012	.002	.004		.002		
MASS NO		3.10	.00	.49				
CROTOMALDE								
PPH		.000	.000	.000		.000		
rass no		.00	.00	.00				
ISOBUTYR+N	IEK							
PPA	,	.022	.006	.010		.005		
nass n		6.88	.68	1.97				
BENTALDERY								
PPN		.000	.000	.000		.000		
MASS M		.00	.00	.00				
HEXANALDEI	iiul	000	000	000		000		
PPM NASS N	^	.000 .00	.000 .00	.000 .00		.000		
JOHAHTEN	J	.00	.00	.00				
PPM		93.944	.199	.612		.201		
MASS W	G 14	6315.29	1.35	72.64		.201		
ELEYNOT		0313.67	1.33	72101				
PPM		,000	.000	.000		.000		
MASS M	G	.00	.00	.00				
3-BAG COMPO	SITE RESULTS							
	FORMALDERYD	E MG/MI	20.094	CROTONALD.	NG/NI	.000		
	ACETALDETYD		.686	ISOBUTYR+NEK	•	-641		
	ACPOLEIN	MG/NI	.000	BENZALDEHYDE	•	.000		
	ACETOME	MG/RI	.707	HEXANALDEHYDE	MG/HI	.000		
	PROPIONALD.	NG/NI	. 216	nethanol ethanol	NG/NI NG/NI	947.966 .000		

COMPUTER PROGRAM LDT 1.0-R 3-BAG CARB FTP VEHICLE EMISSION RESULTS PROJECT NO. 08-4527-008

COMPUTER PROG	1.0° k 3° E	NO COM III TENICOL	FUIOCIAN PROCEID	1800001 80. 00-452: 000
VEHICLE MEMBER	577	ም ድና ቸ <i>ሶ</i> ሶ-ሞሞ-ብን		NETRINGE FW-1300-F
TEST OF MODEL	RE CHEVY CORSICE	DATE 1/20/93	DRN	NETHANOL EM-1399-F FUEL DENSITY 6.620 LB/GAL H .126 C .375 O .499 X .000
PECTUS HOUSE	2 & I (171 CID)-V-6	DVIKO 2 F	uc cirt 2	H .126 C 375 D 499 Y 000
PRINCEL CCLUM	5 8	ארווים בייטודע בייטודע	110 CART 2 110 7 70 FD / 5 74 KI	1 1120 C .5/5 C .4/5 % 1000
COOKETER	- 9258 NTLES / 14896 KW)	TEST WEIGHT 3	8500 ERS (1587 KG)	, ,
ODGILI IIA	seso nimes (14030 ldt)	IBOI WELCONI	1000 EED (\$30) 160)	
BARONETER 29.32	IN HG (744.7 NO HG)	DRY BULB TEKPERATURI	70.0°F (21.1°C)	NOX HUNIDITY C.F892
RELATIVE HUNIDIT	Y 44.2 PCT.		,	
BAG MUMBER		1	2	3
BAC DESCRIPTIO	¥	COLD TRANSIENT	STABILIZED	BOT TRANSIENT
		(0-505 SEC.)	(505-1372 SEC.)	(0- 505 SEC.)
ECH TIME SECON	DS	505.3	867.7	507.1
DRY/WET CORREC	TION FACTOR, SAMP/BACK	. 976/. 9 89	.979/.989	.977/.989
MEASURED DISTA	INCE HILES (KM)	3.57 (5.74)	3.82 (6.15)	3.57 (5.74)
BLOWER FLOW RA	TE SCEN (SCHOL)	557.5 (15.79)	557.1 (15.78)	556.6 (15.76)
gas heter flow	RATE SCFM (SCMM)	.27 (.01)	.27 (.01)	.27 (.01)
TOTAL FLOW SCF	Y 44.2 PCT. N DS TION FACTOR, SAMP/BACK INCE MILES (KM) ITE SCFM (SCION) ITE SCFM (SCION) ITE SCFM (SCION)	4697. (133.0)	8061. (228.3)	4706. (133.3)
WA 211771	EER/RANGE/PPN (BAG) EER/RANGE/PPN EER/RANGE/PPN EER/RANGE/PPN EER/RANGE/PPN EER/RANGE/PCT EER/RANGE/PCT EER/RANGE/PPN (BAG) (D) EER/RANGE/PPN (BAG) (D) EER/RANGE/PPN M (1.120) E OR ATION PPN ATION PPN ATION PPN ATION PPN ATION PPN ATION PPN ATION PPN			
BC SAMPLE NET	CER/RANGE/PPN (BAG)	46.0/ 2/ 45.97	12.1/ 2/ 12.09	12.1/ 2/ 12.09
BC BCKGKD RET	EK/KANGE/PPN	9.4/ 2/ 9.39	11.0/ 2/ 10.99	10.7/ 2/ 10.69
O DOMORD WE	CER/KANGE/PPN	58.1/ 12/ 56.81	13.6/ 12/ 13.06	11.8/ 12/ 11.32
OO BURGED RET	REAL MARGE / PPR	2.9/ 12/ 2.76	2.3/ 12/ 2.19	2.7/ 12/ 2.5/
COS DANGER KE	EEN/BARGE/PC1	77.5/ 14/ .5152	74.5/ 74/ 0400	74.7/ 14/ .3093
MOY CLADE NET	FER / DIMCE / DOM: / DIC \ / IN\	19.4/ 14/ .0494	14.5/ 14/ .0498	7 0 (1 / 1) 6
MOA DUACADO ADA	PER (BANCE / PPR (DAG) (D)	39.9/ 1/ 9.9/	1.5/ 1/ .36	1.0/ 1/ 1.96
WAY STRICK DON	(68) #ARGE/PPR (/1 130)	2.3/ 1/ .38 4.10	2.1/ 1/ ./8	1.0/ 1/ .25
CEA SAMPLE FF	1 (1·120)	3 30	3.70	9.//
CEA DOUGHD !!!	4	1.30	3.10	5.12
DILUTION PACTO	D Ř	18.47	24.58	20,23
EC CONCENTRA	ATTON PPM	37.09	1.55	1.93
CO CONCENTRA	ATION PPN	52.38	10.63	8.56
CO2 CONCENTRA	ATION PCT	.5685	.4202	.5206
NOI CONCENTR	ATION PPN	9.42	37	1.72
CE4 CONCENTR	ATION PPN	.98	.85	1.80
MINIBO CONCENTR	ATION PPH	.00	.59	04
TBC MASS G		8.136	.210	.163
OO HASS G		8.112	2.824	1.328
002 NASS G		1384.57	1756.07	1270.27
NOX HASS G		2.139	.000	.391
CH4 HASS G		.087	.130	.160
NINEC NASS G FUEL NASS K	RAMS (FID)	.000	.078	.000
	MPG (L/100KM)	1.025	1.282	.926
LARY SYMMUS	nro (L/100Mi)	10.45 (22.51)	8.96 (26.26)	11.56 (20.35)
3-BAG COMPOSITE	RESULTS			
	TEC G/MI	.51	CH4 G/MI	.035
	•	.96	NNHC G/NI	.011
	•	.15	CARBONYL G/NI	.005
	/ •••	- 	ALCOHOL G/NI	. 464
	FUEL ECONOMY MPG (L/	100KOK) 9.87 (23.84		.479
	` '		•	

COMPUTER PROGRAM LOT 1.0-R 3-BAG CARB FTP VEHICLE EMISSION RESULTS PROJECT NO. 08-4527-008

VEHICLE MODEL	2.8 L (171 CID)-V-6 5W		RUN BAG CART 2 DAD 7.70 MEP (5.74 KW)	METHANOL EN-1399-F FUEL DENSITY 6.620 LB/GAL E .126 C .375 O .499 X .000	
	.32 IN EG (744.7 NN EG) DITY 44.2 PCT.	DRY BULB TEMPERATURE	E 70.0 F (21.1 C)	MOX HUMIDITY C.F892	
	1	2	3		
		r stabilized		BACKGROUND	
) (505-1372 SEC.)			
FORMALDERYD		(303 1372 1301)	(0 000 0001)		
PPN	.363	.015	.013	.017	
KASS NG		.00	.00	•••	
ACETALDERYD		100	100		
PPM	.012	.003	.001	.002	
MASS NG	2.36	.43	.00		
ACROLEIN	1.30	• • • • • • • • • • • • • • • • • • • •	100		
PPM	.000	.000	.000	.000	
NASS NG	.00	.00	.00	••••	
ACETONE	•••	•••			
PPN	.043	.008	.015	.005	
MASS NG	12.14	1.85	3.09	•	
PROPIONALDE		••••			
PPM	.000	.000	.000	.000	
MASS NG		.00	.00		
CROTOWALDED					
PPM	.000	.000	.000	.000	
NASS NG		.00	.00		
ISOBUTYR+KI					
PPN	.007	.001	.001	.001	
nass ng	2.61	.14	.10		
BEHZALDERY	DE				
PPN	.000	.000	.000	.000	
Mass ng	.00	.00	.00		
REAYNYTDER	YDE				
PPM	.000	.000	.000	.000	
hass ng	.00	.00	.00		
KETHANOL					
PPM	46.346	.274	. 209	. 284	
nass ng	7975.38	.00	.00		
ETHANOL					
PPN	.000	.000	.000	.000	
MASS NO	.00	.00	.00		
3-BAC COMPOS	THE RESULTS				
	FORMALDERYDE NG/NI	3.276	CROTONALD. MG/MI	.000	
	ACETALDERYDE NG/NI	.196	ISOBUTYR+NEK MG/MI	.179	
	ACROLEIN MG/MI	.000	BENZALDEHYDE NG/NI	.060	
	ACETONE NG/HI	1.194	HEXANALDEHYDE NG/NI	.000	
	PROPIONALD. NG/NI	.000	METHANOL MG/MI	463.908	
			ETHANOL NG/NI	.000	

COMPUTER PROCRAM LDT 1.0-R 3-BAG CARB FTP VEHICLE EMISSION RESULTS PROJECT NO. 08-4527-008

VERICLE NUMBER 577 VERICLE NODEL 88 CHE ENGINE 2.8 L TRANSMISSION 5N ODORETER 9258	VY CORSICA (171 CID)-V-6 MILES (14896 KM)	TEST CC-TH-01 DATE 1/19/93 DYNO 2 E ACTUAL ROAD LC TEST WEIGHT 3	RUN NAG CART 2 NAD 7.70 HP (5.74 KW) 1500 LBS (1587 KG)	HETHANOL EM-1399-F FUEL DENSITY 6.620 LB/GAL H .126 C .375 O .499 X .000
BARONETER 29.30 IN BO	(744.2 NON BG)	DRY BULB PEMPERATURE	72.0°F (22.2°C)	HOX HUNIDITY C.F880
RELATIVE HUNIDITY 38.6	PCT.	•	2	3
BAG MUNBER		1	CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR OF THE CONTRACTOR O	TAN UTSINGT HAN
BAG DESCRIPTION		COLD TRANSIENT	STABILIZED	BUI TRANSIENT
		(0-505 SEC.)	(505-1372 SEC.)	(0- 505 SEC.)
ROB TIME SECONDS		505.2	867.0	202.4
DRY, WET CORRECTION	FACTOR, SAMP/BACK	.977/.989	.980/.989	.9/8/.989
REASURED DISTANCE A	ITES (KM)	3.58 (5.76)	3.83 (6.16)	3.5/ (5./4)
BLOWER FLOW RATE SC	FIX (SCHON)	557.2 (15.78)	556.9 (15.77)	556.5 (15.76)
GAS METER FLOW RATE	SCFM (SCFM)	.27 (.01)	.27 (.01)	.27 (.01)
total flow SCF (SCH)	1 COLD TRANSIENT (0-505 SEC.) 505.2 .977/.989 3.58 (5.76) 557.2 (15.78) .27 (.01) 4694. (132.9)	8051. (228.0)	4689. (132.8)
BC SAMPLE METER/RA	NGB/PPN (BAG)	37.8/ 2/ 37.78 7.6/ 2/ 7.60 33.6/ 12/ 32.60 1.1/ 12/ 1.04 77.8/ 14/ .6203 14.0/ 14/ .0478 45.8/ 1/ 11.43 1.5/ 1/ .38 4.29 2.54	11.9/ 2/ 11.89	11.5/ 2/ 11.49
HC BOKGED HETER/RA	NGE/PPN	7.6/ 2/ 7.60	9.9/2/9.89	9.7/ 2/ 9.69
co sample meter/ra	NGE/PPM	33.6/ 12/ 32.60	17.1/ 12/ 16.47	10.6/ 12/ 10.16
OD BOXGRD NETER/RA	NGE/PPN	1.1/12/1.04	1.4/ 12/ 1.33	1.3/ 12/ 1.23
CO2 SAMPLE RETER/RA	NGE/PCI	77.8/ 14/ .6203	67.4/ 14/ .4640	74.1/ 14/ .5601
OO2 BOXGRD HETER/RA	IGE/PCT	14.0/ 14/ .0478	13.7/ 14/ .0466	13.8/ 14/ .0470
HOI SAMPLE METER/RA	MGE/PPM (BAG) (D)	45.8/ 1/ 11.43	2.7/ 1/ .68	27.0/ 1/ 6.77
NON BOKGRD RETER/RA	NGE/PPN	1.5/ 1/ .38	1.9/ 1/ .48	1.1/ 1/ .28
CH4 SAMPLE PPH (1.1	20)	4.29	3.55	4.39
CHA BOKGRD PPH		2.54	2.52	2.51
DILUTION FACTOR		18.42 30.59 30.61 .5751 11.07 1.88	24.78	20.57
EC CONCENTRATION	PPN	30.59	2.40	2.27
CO CONCERTRATION	PPK	30.61	14.77	8.70
CO2 CONCENTRATION	PCT	.5751	,4193	.5154
NOT CONCENTRATION	PPM	11.07	.22	6.51
CH4 CONCENTRATION	PPN	1.88	1.13	2.00
NNEC CONCENTRATION	PPN	.13	1.07	.02
THC HASS GRAMS		6.521	.365	.189
CO MASS GRAMS		4.737	3.920	1.345
CO2 MASS GRAMS		1399.64	1750.06	1253.19
NOX KASS GRANS		2.478	.085	1.454
CH4 NASS GRANS		.167	.172	.178
NOMES NASS GRAMS	(FID)	.010	.141	.001
FUEL RASS KG		1.031	1.279	.914
FUEL ECOMONY MPC (L/100KH)		8.98 (26.18)	
3-BAG COMPOSITE RES			·	·
T	BC G/NI	.44	CH4 G/NI	.047
C	O G/NI	.91	NNHC G/NI	.020
¥	OX G/NI	.27	CARBONYL G/MI	.009
			ALCOHOL G/MI	.367
F	TEL ECOMONY MPG (L	/100KDK) 9.91 (23.73) NHOG G/NI	.396

COMPUTER PROGRAM LIFT 1.0-R 3-BAG CARB FTF VEHICLE EMISSION RESULTS PROJECT NO. 08-4527-008

REMONETER 29.30 IN NG (744, 2 NR NG)	VEHICLE NODEL ENGINE TRANSMISSION	577 88 CHEVY CORSICA 2.8 L (171 CID)-V-6 5N 9258 NILES (14896 KM)	DYNO 2 B ACTUAL ROAD LO	RUN AG CART 2 AD 7.70 HP (5.74 KW)	
BAG DRECKIPTION		ITY 38.6 PCT.		72.0°F (22.2°C)	NOX HUNIDITY C.F880
BASE DESCRIPTION		1	2	3	
Co-505 SEC. (505-1372 SEC.) (0 - 505 SEC.)		ON COLD TRANSIENT	STABILIZED		BACKGROUND
POPM		(0-505 SEC.)	(505-1372 SEC.)	(0- 505 SEC.)	
NLSS NC 38.71 .00 .00 .00	PORTEALDERYDE				
PPH	PPK	.252	.008	.011	.014
PPN	MASS NG	38.71	.00	.00	
PPN	ACETALDEHYDE				
PPH			.015	.005	.002
PPH	NASS NG	7.83	5.54	.65	
MASS NG 4.39 .00 .00 ACETORIE PPR					
ACETOME	PPN	.015	.000	.000	.000
PPN	MASS MG	4.39	.00	.00	
MASS NG	ACETOME				
PROPIONALDERYDE PPN	PPK	.048	.059	.036	.013
PPN	MASS ING	11.22	25.06	7.57	
NASS NG 3.13 .00 .000 CROTONALDERYDE PPN .000 .000 .000 .000 NASS NG .00 .00 .00 .000 ISOBETYTHEX PPN .000 .001 .000 .001 NASS NG .00 .001 .000 .001 NASS NG .00 .004 .000 BEBLALDERYDE PPN .000 .000 .000 .000 NASS NG .00 .00 .000 .000 RELAMALDERYDE PPN .000 .000 .000 .000 NASS NG .00 .00 .000 .000 NASS NG .00 .00 .00 .00 NASS NG .00 .00 .00 .00 NETRANOL PPN 36.444 .238 .173 .171 NASS NG 6279.27 21.59 1.45 ETELNOL PPN .000 .000 .000 .000 NASS NG .00 .00 .000 NASS NG .00 .00 .000 NASS NG .00 .000 .000 NASS NG .00 .000 .000 NASS NG .00 .000 .000 NASS NG .00 .000 .000 .000 NASS NG .00 .000 .000 .000 NASS NG .00 .000 .000 .000 NASS NG .00 .000 .000 .000 NASS NG .00 .000 .000 .000 NASS NG .000 .000 .000 .000 NASS NG .000 .000 .000 .000 NASS NG .000 .000 .000 .000 NASS NG .000 .000 .000 .000 .000 NASS NG .000 .000 .000 .000 .000 NASS NG .000 .000 .000 .000 .000	PROPIONALDEH	YDE			
CROTOMALDERYDE PPN .000 .000 .000 .000 RASS NG .00 .00 .000 .000 ISOBCTYR*HEX PPN .000 .001 .000 .001 BASS NG .00 .004 .000 BEBEALDERYDE PPN .000 .000 .000 .000 RASS NG .00 .00 .000 .000 RECAMALDERYDE PPN .000 .000 .000 .000 RELAMALDERYDE PPN .000 .000 .000 .000 RASS NG .00 .00 .000 .000 RASS NG .00 .00 .000 .000 RASS NG .00 .00 .000 .000 RASS NG .00 .00 .000 .000 RASS NG .00 .00 .000 .000 RASS NG .00 .00 .000 .000 RASS NG .00 .000 .000 RASS NG .000 .000 .000 RASS NG .000 .000 .000 RASS NG .000 .000 .000 RASS NG .000 .000 .000 RASS NG .000 .000 .000 RASS NG .000 .000 .000 RASS NG .000 .000 .000 RASS NG .000 .000 .000 RASS NG .000 .000 .000 RASS NG .000 .000 .000 RASS NG .000 .000 .000 RASS NG .000 .000 .000 RASS NG .000 .000 .000 RASS NG .000 .000 .000 RASS NG .000 .000 .000 RASS NG .000 .000 .000 .000 RASS NG .000 .000 .000 .000 RASS NG .000 .000 .000 .000 RASS NG .000 .000 .000 .000	PPK	.010	.000	.000	.000
PPN	MASS MG	3.13	.00.	.00	
NASS NG	CROTONALDERY	Œ			
ISOBLTYR+NEX	PPW	.000	.000	.000	.000
PPM	NASS NG	.00	.00	.00	
NASS NG	ISOBCTYR+REX				
PPH	PPM	.000	.001	.000	.001
PPH	MASS NG	.00	.04	.00	
NASS NG	BENIALDEHYDE				
### 1.000	PPM	.000	.000	.000	.000
PPN .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .	XLASS NG	.00	.00	.00	
NASS NG .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00	REXAMALDERY	30			
PPH 36.444 .238 .173 .171 NASS NG 6279.27 21.59 1.45 ETBANOL PPH .000 .000 .000 .000 NASS NC .00 .00 .00 .00 S-BAG COMPOSITE RESULTS PORNALDEHYDE NG/NI 2.247 CROTONALD. NG/NI .000 ACRETALORHYDE NG/NI 1.253 ISOBUTYR+NEK NG/NI .005 ACROLEIN NG/NI .255 BENZALDEHYDE NG/NI .000 ACETONE NG/NI 4.622 HEXANALDERYDE NG/NI .000	PPM	.000	.000	.000	.000
PPH 36.444 .238 .173 .171 NASS NG 6279.27 21.59 1.45 ETRANOL	nass ng	.00	.00	.00	
RASS NG 6279.27 21.59 1.45	NETHANOL				
ETRAMOL PPN .000 .000 .000 .000 .000 NASS NC .00 .00 .00 .00 .00 3-BAG COMPOSITE RESULTS FORNALDEHYDE NG/NI 2.247 CROTONALD. NG/NI .000 ACETALDEHYDE NG/NI 1.253 ISOBUTYR+NEK NG/NI .005 ACBOLEIN NG/NI .255 BENZALDEHYDE NG/NI .000 ACETONE NG/NI 4.622 HEXANALDEHYDE NG/NI .000	PPK	36.444	.238	.173	.171
PPN .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000	NASS NG	6279.27	21.59	1.45	
NASS NC .00 .00 .00 3-BAG COMPOSITE RESULTS FORMALDEHYDE NG/NI 2.247 CROTONALD. NG/NI .000 ACETALDEHYDE NG/NI 1.253 ISOBUTYR+NEK NG/NI .005 ACEOLEIN NG/NI .255 BENZALDEHYDE NG/NI .000 ACETOME NG/NI 4.622 HEXANALDEHYDE NG/NI .000	ETRANOL				
3-BAG COMPOSITE RESULTS FORMALDEHYDE MG/NI 2.247 CROTONALD. MG/NI .000 ACETALDEHYDE MG/NI 1.253 ISOBUTYR+NEK MG/NI .005 ACEOLEIN MG/NI .255 BENZALDEHYDE MG/NI .000 ACETOME MG/NI 4.622 HEXANALDERYDE MG/NI .000			-000		.000
FORMALDEHYDE NG/NI 2.247 CROTONALD. NG/NI .000 ACETALDEHYDE NG/NI 1.253 ISOBUTYR+NEK NG/NI .005 ACEOLEIN NG/NI .255 BENZALDEHYDE NG/NI .000 ACETOME NG/NI 4.622 HEXANALDEHYDE NG/NI .000	nass nc	.00	.00	.00	
ACETALDERYDE NG/NI 1.253 ISOBUTYR+NEK NG/NI .005 ACEOLEIN NG/NI .255 BENZALDERYDE NG/NI .000 ACETOME NG/NI 4.622 HEXANALDERYDE NG/NI .000	3-BAG COMPOSI	TE RESULTS			
ACETALDERYDE NG/NI 1.253 ISOBUTYR+NEK NG/NI .005 ACEOLEIN NG/NI .255 BENZALDERYDE NG/NI .000 ACETOME NG/NI 4.622 HEXANALDERYDE NG/NI .000		FORMALDEHYDE MC/MI	2.247	CROTONALD. KG/KI	.000
ACETOME MG/MI 4.622 HEXANALDERYDE MG/MI .000					.005
ACETOME MG/MI 4.622 HEXANALDERYDE MG/MI .000		ACROLEIN NG/HI	. 255		.000
PROPIONALD. NG/NI .182 NETHANOL NG/NI 367.478		· · · · · · · · · · · · · · · · · · ·	4.622	HEXANALDERYDE MG/NI	.000
		PROPIONALD. NG/NI	.182	nethanol ng/ni	367.478

ETHANOL

MG/KI

.000

APPENDIX D

Initial Oil Cnsumption Test Results from Southwest Research Institute

SOUTHWEST RESEARCH INSTITUTE

6220 CULEBRA ROAD ● POST OFFICE DRAWER 28510 ● SAN ANTONIO, TEXAS JSA 78228-0510 ● (512) 684-5111 ● TELEX 244846

ENGINE, FUEL, AND VEHICLE RESEARCH DIVISION TELECOPIER: 512/522-2019

July 7, 1992

Dr. Tim Maxwell
Department of Mechanical Engineering
Texas Tech University
Lubbock, Texas 79409
Fax. 806-742-3540

Subject: Southwest Research Institute Preproposal No. EVR-1126,

"Oil Consumption Measurement for A Methanol Vehicle Under Emission Cycle"

Dear Dr. Maxwell:

We are pleased to submit the above preproposal. The following is the content of the proposed tasks.

OBJECTIVE

The objective of this proposal is to measure oil consumption of a methanol vehicle on chassis dynamometer under EPA Federal Test Procedure.

APPROACH

The approach is to use the on-line oil consumption measurement system developed by SwRI using SO₂ tracer method. I have enclosed two SAE papers and one brochure for your reference. This literature describes the capability of the on-line oil consumption measurement system. Currently, the system uses relatively long exhaust gas sampling line as described in the literature and it is not appropriate for the FTP transient cycle test. However, another system is being setup in the one of SwRI engine test cell. This new system will be able to measure true real-time oil consumption; therefore, it is appropriate for the proposed project and planned for the proposed project.

Briefly, the engine will be operated on relatively high sulfur oil (~1%wt). This oil has good sulfur balance over a certain distilled fraction and it will be available for the proposed project. Since the fuel is methanal, there is no provision necessary for the fuel preparation in terms of sulfur content. By knowing fuel and air flow rate, the oil consumption in grams per unit time can be calculated by measuring SO₂ concentration in the exhaust gas since sulfur concentration in the oil is known. SwRI has developed a PC data acquisition system for the online oil consumption measurement. The oil consumption will be continuously monitored and stored for the data analysis.



Dr. Tim Maxwell Texas Tech University Southwest Research Institute EVR-July 7, 1992 Page 2

PROJECT TASK

Pretest Preparation

The oil consumption measurement system will be relocated to the vehicle emissions test laboratory of Department of Emissions Research at SwRI and prepared for the measurement. The engine will have to be run on no sulfur oil for a while in order to eliminate sulfur background. This test will usually last about 4 to 8 hours. Then, the oil is replaced with the qualified high sulfur oil, and the preliminary test will be conducted for making sure all the instrumentation functions. As soon as the measurement results are determined to be acceptable, the vehicle test under the FTP transient cycle will be initiated as follows.

Test 1

The oil consumption under the FTP transient cycle will be measured before the vehicle is tested for the long term road test. The oil consumption measurement results will be analyzed and plotted against the test time.

Test 2

The oil consumption under the FTP transient cycle will be measured after the vehicle test is completed. The oil consumption measurement results will be analyzed and plotted against the test time.

REPORTING

A comprehensive final report will be prepared and submitted to Texas Tech University at the completion of the project.

COST AND TIME ESTIMATE

The cost plus fixed fee contract cost estimate is \$41,000. The estimate project duration is two (2) months. Upon receiving your acceptance, SwRI will prepare a formal proposal and submit it to Texas Tech University with contractual documentation.

CLOSURE

Engine tribological problems associated with Alcohol engines still exist. The result of this project is expected to provide an additional information useful for investigating such problems. It is particular interest to observe how much of the effect of component dimensional change due to the wear on the oil consumption will affect the emissions characteristics under transient conditions. SwRI is very interested in participating to the program and hoping to provide Texas Tech University the valuable results

Dr. Tim Maxwell Texas Tech Univeristy Southwest Research Institute EVR-July 7, 1992 Page 3

If you have any questions, please feel free to call me at 512-522-3194. Our facsimile number of 512-522-2019 for your convenience.

Sincerely,

Susumu Ariga Acting Manager

Engine Tribology Section

Department of Engine Research

Approved:

Shannon Vinyard, Director Department of Engine Research

/sjh

SOUTHWEST RESEARCH INSTITUTE

5220 CULEBRA REAC . POST OFFICE DRAWER 1850. . AN ANTONIC (EXAC USA 78728 0510. . COLORA 5111. . TELEX 244846

ENGINE, FUEL, AND VEHICLE RESEARCH DIVISION TELECOPIER (210) 522-2019

April 23, 1993

Dr. Tim Maxwell Professor Department of Mechanical Engineering Texas Tech Research Lubbock, Texas 79409 Fax: 806-742-3540

Subject: Progress Report No. 1 for Southwest Research Institute Project 03-5461,

"Oil Consumption Measurement for A Methanol Vehicle Under Emission Cycle"

Dear Dr. Maxwell:

This is the first progress report for the subject project. The work has been completed for the first oil consumption meaurement as Test 1, and the car has been picked up by a student from Texas Tech Research. The following describes the work accomplishment, problems, and future plans.

OBJECTIVE

The objective of this project is to measure oil consumption of a methanol vehicle on a chassis dynamometer under EPA Federal Test Procedures before and after the vehicle durability tests.

WORK ACCOMPLISHMENTS

The oil consumption measurement system was refined to increase the sampling response time by means of electronic sample gas pressure closed loop control in order to increase the accuracy of the measurement under transient operating conditions. The device was designed, fabricated, and tested by actually conducting the oil consumption measurement on one engine installed at SwRI. After the acceptable gas sampling response time (less than one second) was determined, the oil consumption measurement system hardware and a PC data acquisition system were relocated from the engine research laboratory to the vehicle emissions test laboratory and prepared for the measurement.

In order to prepare for the oil consumption testing, the methanol powered vehicle (GM Corsica 2.8 liter V6 engine) was instrumented for flow rates of intake air and fuel and engine pertinent temperatures and pressures. A laminar flow element (LFE) with pressure transducers was used for the intake air flow measurement in real-time, and a micro-motion real-time mass fuel flow meter was used for fuel flow measurement. An exhaust gas sampling probe was fitted



Dr. Tim Maxwell Texas Tech Research April 23, 1993 Page 2

to the exhaust pipe close to the manifold flange. The original oil was drained, saved, and a zero sulfur synthetic oil was installed. The vehicle was then driven at normal operating temperatures to mix the zero sulfur oil with any residue of the original oil. This process was repeated through three changes of zero sulfur oil to insure that any sulfur residue from the original oil had been flushed from the system.

The vehicle was installed on the dynamometer and tested to establish baseline performance of the oil consumption instrumentation with zero sulfur oil in the vehicle. The zero sulfur oil was then drained, and replaced for the balance of the testing with an oil of known sulfur concentration that has proven to be very stable in maintaining this fixed concentration throughout the testing cycle.

The test preparation went smoothly. The EPA Urban Dynamometer Driving Test cycle was performed on the vehicle from cold start condition, followed by a repeat of the cycle from hot start condition. The total length of the test is approximately 60 minutes, including soaking time, and the actual vechicle operating time is 40 minutes. In addition, the vehicle was operated under three steady-state conditions to obtain additional oil consumption information from this particular vehicle. The results are descussed below.

After the completion of the first test, the vehicle was returned to Texas Tech on April 12, 1993.

PROBLEMS

The oil consumption measurement system had a problem dealing with the SO_2 detection instrumentation. The problem was found when the system was being used for another SwRI project. The correction could be made; however, it took about one month to complete the investigation and applying the solution. The problem was that the NO_X signal interfered with the SO_2 signal. Therefore, the measured SO_2 concertation was actually higher than the true value. This incident delayed the test schedule by about one month.

DISCUSSION OF TEST 1 RESULTS

The EPA Urban Dynamometer Driving Test cycle was performed on the vehicle from cold start condition, followed by a repeat of the cycle from hot start condition. Figures 1 and 2 represent plots of real-time oil consumption and vehicle speed during these two test cycles. Note that Figure 1, the cold start cycle, shows considerably less oil consumption during the first 800 seconds of the cycle when compared to the hot start cycle of Figure 2. Figures 3 through 9 illustrate these same two test cycles plotted together, but with an expanded time base to allow a more detailed comparison. While changes in vehicle speed during these test cycles is the primary cause of variations in oil consumption, engine temperature seems to be another major contributor. Figures 10 and 11 show coolant temperature out of the block, plotted with oil consumption. Note that the low oil consumption during the first 800 seconds of the cold start test, Figure 10, shows lower temperatures during the same time period.

Dr. Tim Maxwell Texas Tech Research April 23, 1993 Page 3

Following the cycling tests, three additional tests were performed at steady-state conditions. These were 2675 RPM in fourth gear, 1500 RPM in fifth gear, and idle at 900 RPM. Results of these tests are presented in Figures 12 through 14. It is quite apparent in these figures that engine temperature, as monitored by coolant temperature, has a very marked effect on the oil consumption. These data suggest that total engine oil consumption could be significantly reduced by a moderate reduction in coolant temperature perhaps to as low as 180°F. It will be extremely important when the vehicle has accumulated the required road miles and is returned to have these tests repeated, that the engine temperatures are duplicated very closely so that any variations in oil consumption reflect only effects of the accumulated miles.

FUTURE PLANS

Test 2 will commence after the vehicle durability test is completed. The vechile durability test will be conducted by Texas Tech Research.

If you have any questions, please feel free to call me at 210-522-3956. Our facsimile number of 512-522-2019 for your convenience.

Sincerely,

Jim Barbee

Engineering Technologist

Department of Engine Research

Approved:

Susumu Ariga, Acting Manager

Engine Tribology

Department of Engine Research

ckh

EPA URBAN DYNAMOMETER DRIVING TEST FROM COLD START USING METHANOL FUEL

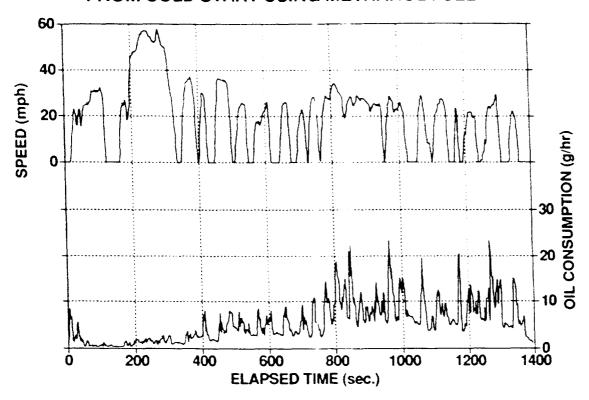


FIGURE 1

EPA URBAN DYNAMOMETER DRIVING TEST FROM HOT START USING METHANOL FUEL

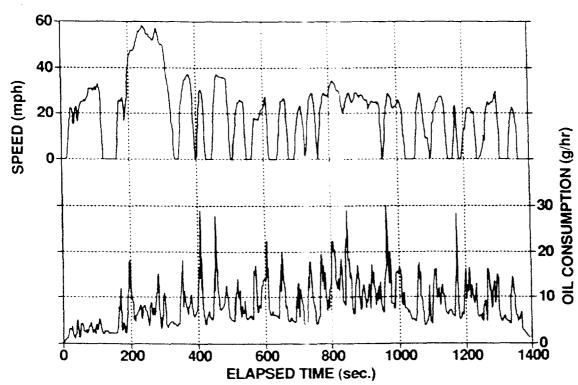


FIGURE 2

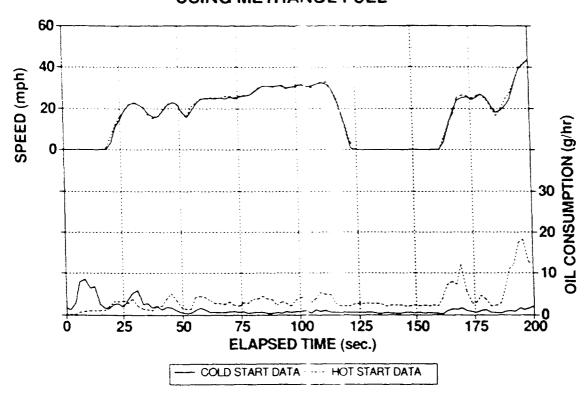


FIGURE 3

EPA URBAN DYNAMOMETER DRIVING TEST USING METHANOL FUEL

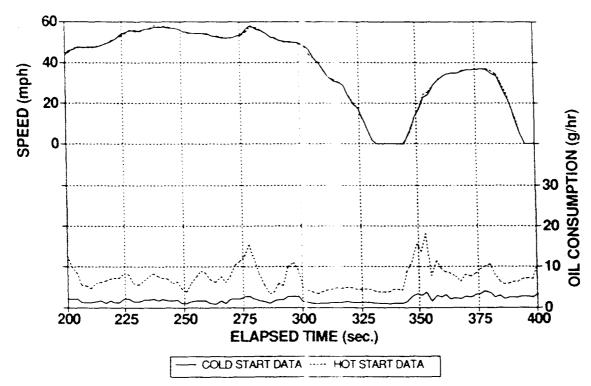


FIGURE 4

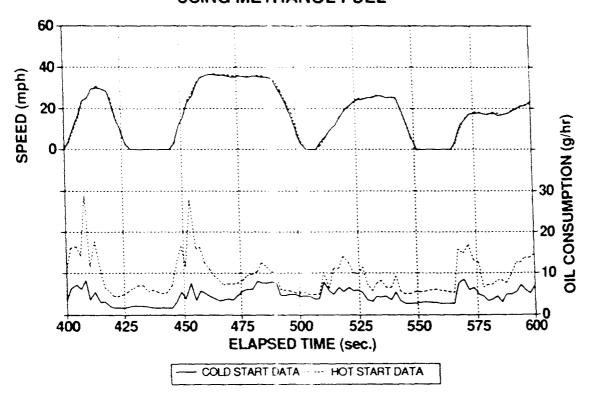


FIGURE 5

EPA URBAN DYNAMOMETER DRIVING TEST USING METHANOL FUEL

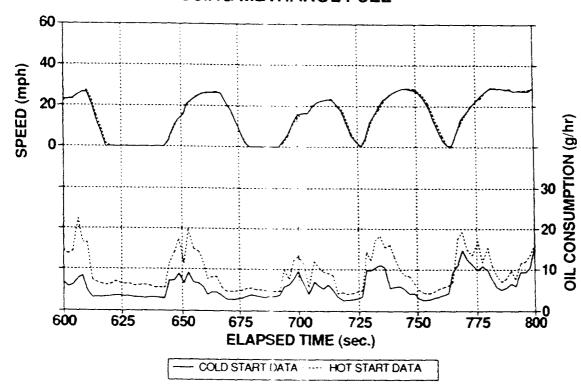


FIGURE 6

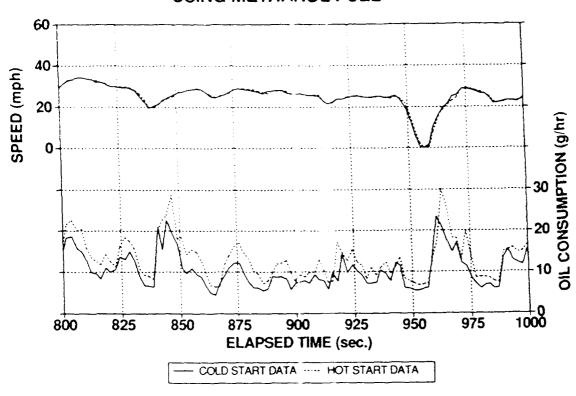


FIGURE 7

EPA URBAN DYNAMOMETER DRIVING TEST USING METHANOL FUEL

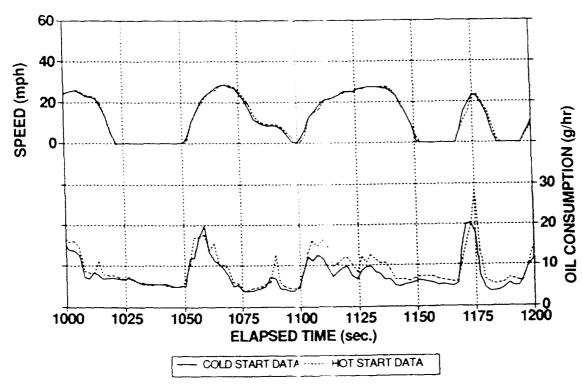


FIGURE 8

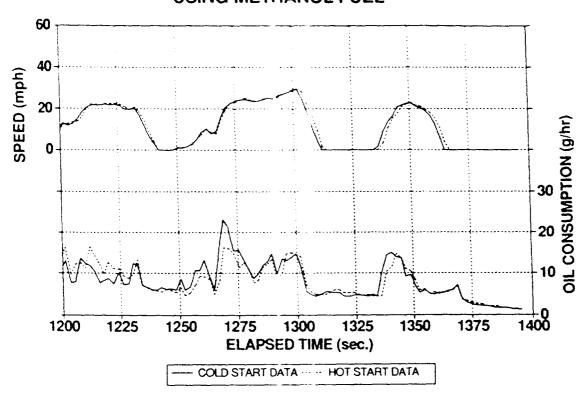


FIGURE 9

EPA URBAN DYNAMOMETER DRIVING TEST FROM COLD START USING METHANOL FUEL

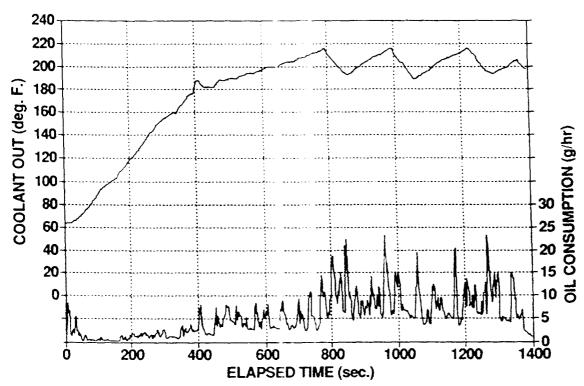


FIGURE 10

EPA URBAN DYNAMOMETER DRIVING TEST FROM HOT START USING METHANOL FUEL

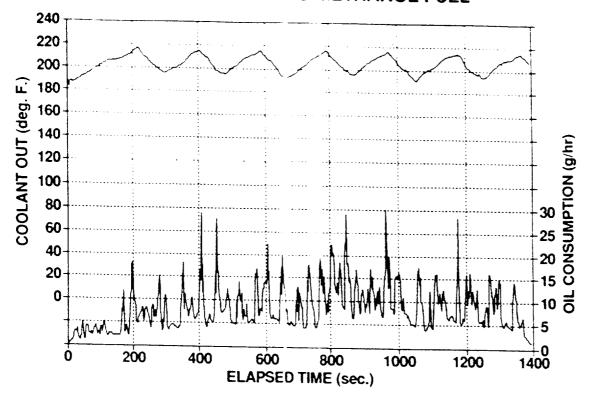


FIGURE 11



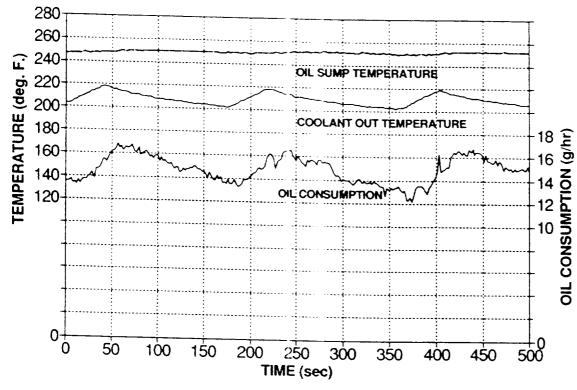


FIGURE 12

1500 RPM STEADY STATE CONDITION

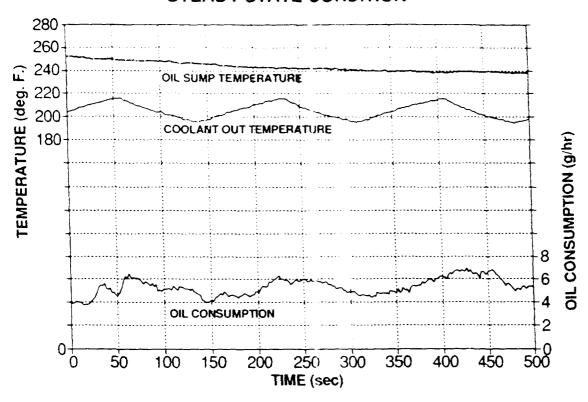


FIGURE 13



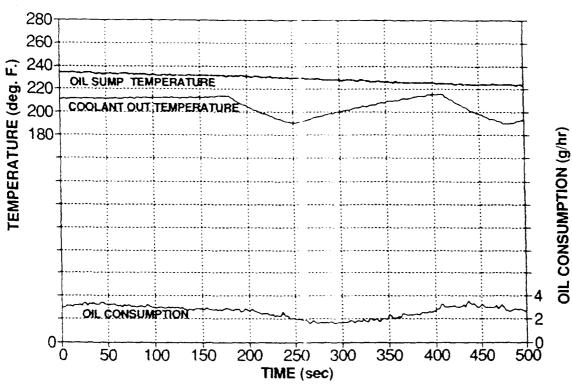


FIGURE 14

APPENDIX E

Final Oil Consumption Test Results from Southwest Research Institute

OIL CONSUMPTION MEASUREMENT FOR A METHANOL VEHICLE UNDER EMISSIONS CYCLE

SwRI Project No. 03-5461

Prepared for:

Dr. T. Maxwell
Professor
Department of Mechanical Engineering
Texas Tech Research Foundation
P.O. Box 43106
Lubbock, Texas 79409-3106

Prepared by:

Susumu Ariga

Approved:

S. M. Shahed

Director

Department of Engine Research

Engine and Vehicle Research Division

EXECUTIVE SUMMARY

Methanol-fueled engines have a higher wear rate of power cylinder components, especially when the vehicle is operated under cold temperature conditions. Excessive components' wear may increase blowby gas flow and oil consumption. Oil deterioration is, then, accelerated and an increased amount of lubricant additives emits to the exhaust system, contributing to the catalyst deactivation.

The objective was to measure the oil consumption of a methanol-fueled vehicle under the conditions of the EPA dynamometer urban driving cycle test procedure. The Southwest Research Institute (SwRI) developed on-line oil consumption measurement system was employed to accomplish the real-time measurement of oil consumption under transient operating conditions. Oil consumption was measured before and after the vehicle accumulated a driving distance of more than 20,000 miles under city driving conditions and was compared to evaluate the effect of the durability test.

The oil consumption rate (g/hr) increased during the durability test. The degree of the increase varied, depending on the measurement conditions under either a cold- or hot-start test. The average oil consumption rate measured under the cold-start transient test conditions increased by 26 percent and that measured under the hot-start transient conditions increased by 9 percent.

Oil consumption over the duration of the EPA urban cycle (~1400 seconds) was significantly higher (52 percent) under the hot-start conditions than under the cold-start conditions. This trend was the same, regardless of pre- or post-durability testing, although the difference measured in the post-durability test was lower (31 percent).

Oil consumption of the post-durability test measured under steady-state conditions significantly increased (223 percent) when the engine speed was relatively high, e.g., 2950-rpm.

Whether the level of increase is high or low is not certain because there was no oil consumption data obtained for the gasoline engine under the same test procedure. Therefore, it is recommended that oil consumption of the gasoline engine be measured for comparison. A comprehensive test is recommended to understand the relationship between oil consumption, catalyst efficiency, and lubricant additives trapped in the catalyst in order to determine the significance of oil consumption increase for a long driving distance. Further investigation will be necessary to explain the high increase in oil consumption measured under a steady-state condition after the durability test has been completed.

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1.0 BACKGROUND

Wear of the power cylinder components of a methanol engine is higher than that of a gasoline engine, especially under cold temperature operating conditions. The primary reason is the corrosiveness of methanol combustion products formed in the crevices of the piston and ring pack. A large degree of component wear increases blowby and oil consumption in a relatively short time. A high blowby increases the rate of lubricant deterioration. An increased oil consumption accelerates the catalyst deactivation due to chemical poisoning caused by the lubricant additives. Specially-formulated lubricant additives are normally used to reduce the wear of a methanol engine's components. However, there has not been test data available to show the level of oil consumption increases caused by component wear, especially those under transient operating conditions.

2.0 OBJECTIVE

The objective is to measure the oil consumption of a methanol vehicle on chassis dynamometer under the EPA dynamometer urban driving cycle test procedure before and after the vehicle durability test has been completed.

3.0 TEST APPARATUS AND PROCEDURE

The SwRI-developed on-line oil consumption measurement system has been used to measure oil consumption under step transients. The sampling gas pressure was manually controlled to maintain a certain level to achieve an acceptable measurement accuracy. It is impossible to manually adjust the sampling gas pressure under the EPA's transient cycle. Thus, the gas sampling technique was refined with an electronic, closed-loop control system. The sampling gas pressure was maintained at constant, regardless of speed and load change. This provision achieved the accuracy of the oil consumption measurement under transient conditions.

In order to prepare for oil consumption testing, the methanol-fueled vehicle (GM Corsica 2.8 liter V6 engine) was instrumented for flow rates of intake air and fuel, and engine pertinent temperatures and pressures. A laminar flow element (LFE) with pressure transducers was used for the intake air flow measurement in real-time, and a micro-motion, real-time mass fuel flow meter was used for fuel flow measurement. An exhaust gas sampling probe was fitted to the exhaust pipe close to the manifold flange. The standard oil was drained, saved, and a zero sulfur synthetic oil was installed. The vehicle was, then, driven at normal operating temperatures to mix the zero sulfur oil with any residue of the original oil. This process was repeated through three changes of zero sulfur oil to insure that any sulfur residue from the original oil had been flushed from the system.

The vehicle was installed on the chassis dynamometer and tested to establish baseline performance of the oil consumption instrumentation with zero sulfur oil in the vehicle. The zero sulfur oil was then drained and replaced, for the balance of the testing, with an oil of known sulfur concentration that has proven to be thermally stable in maintaining the fixed concentration throughout the testing cycle.

The EPA urban dynamometer driving test cycle was performed on the vehicle from cold-start conditions, followed by a repeat of the cycle from hot-start conditions. The total length of the test is approximately 60 minutes, including soaking time, and the actual vehicle operating time was 40 minutes. In addition, the vehicle was operated under three steady-state conditions to obtain additional oil consumption information from this particular vehicle. The same tests were repeated after the vehicle was returned from the field test. The results are discussed below.

4.0 DISCUSSION OF THE TEST RESULTS

The Effect of a 21,000 Mile Durability Test: Figures 1 and 2 show plots of cumulative oil consumption in gram and vehicle speed during two test cycles. Each figure also shows the results obtained before (9,260 miles) and after the durability test (31,050 miles) was completed. The effect of the durability test (21,790 miles) was significant when the test was conducted under the cold-start conditions. Oil consumption increased by 26 percent after the durability test was completed. Under the hot-start conditions, the increase, due to the durability test, was 9 percent.

EPA URBAN DYNAMOMETER DRIVING TEST TEST #1 vs TEST #2, COLD START 60 40 SPEED (mph) 20 0 TOTAL O.C. (g) -20 TEST 1 -60 600 800 200 400 1000 1200 1400 ELAPSED TIME (sec.)

FIGURE 1. OIL CONSUMPTION MEASURED UNDER COLD-START EPA URBAN DYNAMOMETER DRIVING TEST CYCLE

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EPA URBAN DYNAMOMETER DRIVING TEST TEST #1 vs TEST #2, HOT START

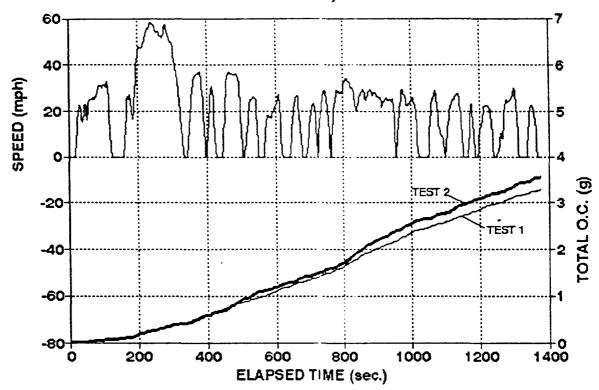


FIGURE 2. OIL CONSUMPTION MEASURED UNDER HOT-START EPA URBAN DYNAMOMETER DRIVING TEST CYCLE

The Effect of Cold- and Hot-Start: The difference in oil consumption between cold- and hot-start was high and the trend was the same, regardless of the pre- and the post-durability test, e.g., 52 and 31 percent, respectively. Figure 3 compares the average oil consumption rate in g/hr between cold- and hot-start and that between pre- and post-durability test.

Coolant temperature of the first 800 seconds was quite different between the cold and the hot-start test as shown in Figure 4. Thus, the difference in oil consumption between cold- and hot-start could primarily be caused by the difference in component temperatures. Low viscosity oil at high component temperature increases oil flow through the ring pack, while it decreases oil film thickness on the cylinder wall. The oil flow increase, due to the low viscosity, was probably significant enough to increase the amount of oil present in the cylinder compared to the oil volume reduction due to a reduced oil film thickness. Therefore, the amount of oil supplied to the combustion chamber likely increased, causing it to increase oil consumption under hot-start conditions. The trend of high oil consumption under hot-start conditions was the same, regardless of pre- and post-durability test.

OIL CONSUMPTION UNDER EPA URBAN CYCLES 2.8-L V-6 METHANOL ENGINE

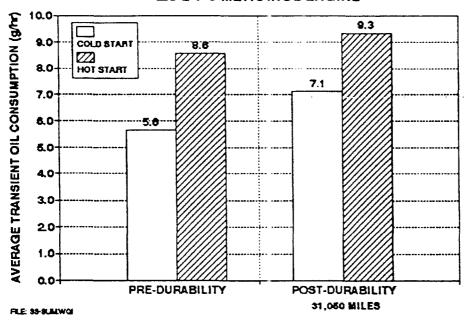


FIGURE 3. AVERAGE OIL CONSUMPTION RATE DURING TRANSIENT CYCLE

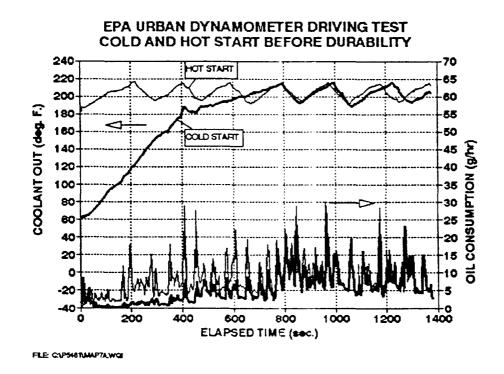


FIGURE 4. COOLANT TEMPERATURE DIFFERENCE BETWEEN COLD-AND HOT-START

Steady-State Tests: Following the transient cycle tests, three additional tests were performed under steady-state conditions. These were a 2675-rpm engine speed in fourth gear, 1500-rpm in fifth gear, and idle at 900-rpm. Results of these tests are presented in Figure 5. The increase in oil consumption of the post-durability test was significant at a higher engine speed. At 2675-rpm, the oil consumption of the post durability test was more than double (223 percent) compared to that of the pre-durability test. The rate of increase was significantly higher than that observed in the results obtained under transient cycles. A further investigation will be necessary to understand the differences observed between the steady-state and transient test results.

OIL CONSUMPTION UNDER STEADY-STATE 2.8-L V-6 METHANOL ENGINE

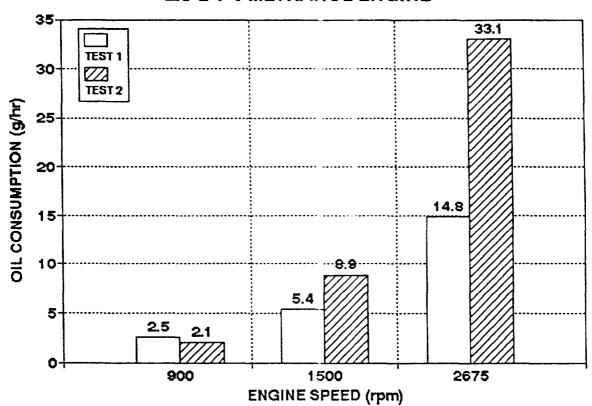


FIGURE 5. OIL CONSUMPTION UNDER STEADY-STATE CONDITIONS BEFORE (TEST 1) AND AFTER (TEST 2) THE DURABILITY TEST

Summary: Since there was no gasoline engine data, a comparison could not be made to determine the level of oil consumption increase measured in the methanol engine after the durability test was completed. However, a rough estimate of oil consumption over 100,000 miles can be made with the results obtained in this project. Oil consumption of the post-durability test (about 21,000 miles) increased by 9 to 26 percent, depending on whether there was a hot- or cold-start operating condition. In 100,000 miles, oil consumption could increase by 1.43 to 2.23 times, depending on cold- and hot-start, and on the assumption that the effect of component wear or other factors on the oil consumption increase remain the same throughout the 100,000 miles. The oil consumption rate, however, is likely to increase as the vehicle accumulates its mileage,

and it increases exponentially rather than linearly. Thus, the oil consumption increase will probably be greater than the above estimate.

The impact of the oil consumption increase is catalyst poisoning. Figure 6 shows the data found in the referenced literature regarding the relationship between hydrocarbon conversion efficiency of the catalyst and the amount of phosphorous contained in lubricating oil reaching the catalyst. Suppose the amount of phosphorous increased by a factor of 2 because oil consumption increase was twice the above estimate, the catalyst efficiency drops by about 10 percent. This may not appear significant; however, the increase in hydrocarbon emissions downstream of the catalyst becomes about 50 percent higher on the assumption that hydrocarbon emissions out of the engine do not change. In reality, the emissions out of the engine also increase as the vehicle accumulates miles. Therefore, the catalyst poisoning must be reduced. If engine oil no longer requires such additives as ZDDP, yet low component wear is warranted, the catalyst poisoning could be minimized. Otherwise, oil consumption should be reduced to a minimum level.

Research into the details of the relationship between oil consumption, catalyst efficiency, and additives accumulated reaching to the catalyst is one subject that should be considered for future research. The results will provide quantitative characterization of the effect of oil consumption on catalyst poisoning and will help to determine the level of oil consumption that should be targeted for future engines.

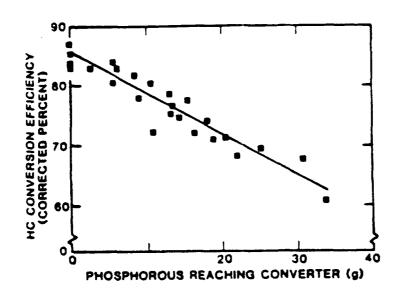


FIGURE 6. THE RELATIONSHIP BETWEEN HYDROCARBON CONVERSION EFFICIENCY AT A CATALYST AND THE AMOUNT OF PHOSPHOROUS REACHING THE CATALYST

¹J. A. Spearot and F. Carraciolo, "Engine Oil Phospherus Effects on Catalytic Converter Performance in Federal Durability and High Speed Vehicle Tests," SAE Transaction, Vol. 86, 1977.

5.0 CONCLUSIONS

- 1. Oil consumption of a methanol-fueled vehicle under the EPA urban driving test cycle was successfully measured with the sulfur tracer technique.
- 2. Vehicle durability tests of more than 20,000 miles increased oil consumption by 26 percent under cold-start conditions and by 9 percent under hot-start conditions.
- 3. Oil consumption under hot-start conditions was higher than under cold-start conditions, by as much as 56 percent.
- 4. The effect of component temperatures on oil viscosity appears to be the primary cause of high oil consumption under hot-start conditions.
- Oil consumption under steady-state conditions significantly increased (223 percent) at a 2675-rpm engine speed after the durability test was completed.

6.0 RECOMMENDATIONS

- 1. It is recommended that oil consumption of a gasoline-fueled vehicle be measured under conditions similar to those used for the methanol-fuel vehicle in order to normalize the effect of methanol operation on the oil consumption.
- 2. The relationship between oil consumption, catalyst efficiency, and additives trapped in the catalyst should be investigated by obtaining the measurement results of all three variables at the same time. The results will be useful in understanding whether catalyst poisoning due to lubricant additives is serious.
- 3. A further investigation will be necessary to understand the differences in the degree of oil consumption increase depending on steady-state and transient conditions.

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